

NOVEMBER 2010

# NATIONAL GEOGRAPHIC

INTERACTIVE EDITION

MYSTERIES OF

# Great Migrations

What Guides Them  
Into the Unknown?



**WORLD'S  
AMAZING  
MIGRATIONS**  
Interactive  
Exclusive



**LITTLE IDEAS THAT CAN  
CHANGE THE WORLD**  
—  
**Dreams of Southern Sudan**  
—  
**Where's the Aztec Emperor?**

NATIONAL  
GEOGRAPHIC

VOL. 218 · NO. 5

# November 2010

**Cover Story**

## Great Migrations

Birds, butterflies, and beasts  
take off. Humans interfere.

## Sudan's Lost Herds

They survived civil war yet  
still need protection.

E-EXTRA: **Hi-Res Exclusive Graphic**

OFFICIAL JOURNAL OF THE NATIONAL GEOGRAPHIC SOCIETY

MORE >





November 2010 | Features

## Southern Sudan's Shaky Peace

The scars and hopes of a boy named Logocho mirror his land.

## Japan's

E-EXTRA: VIDEO





MORE ➤

## Seas

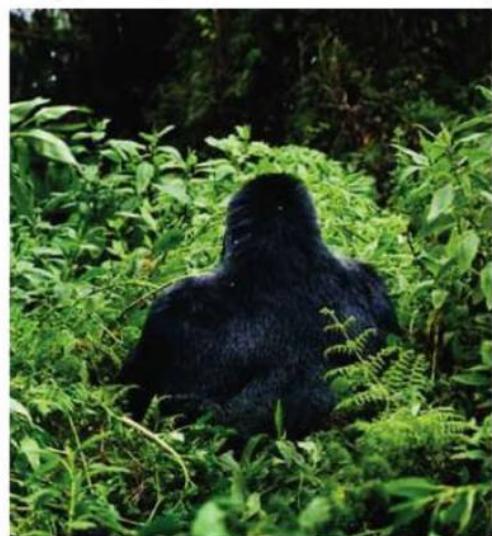
- Swim with their fanciful fish.

## Unburying the Aztec

Diggers find eagles, knives, but no tomb.



## November 2010 | Departments



### **Editor's Note**

VIDEO

### **Letters**

### **Your Shot**

SLIDE SHOW

### **Photo Journal**

E-EXTRA: VIDEO

### **Visions of Earth**

---

### **Inside Geographic Flashback**

### **On the Cover**

Wildebeests kick up dust as they barrel across Liuwa Plain National Park in Zambia at sunset.  
*Photo by Chris Johns*

### **CONSERVATION** **Tracking Gorillas**

Humans make them nervous. So census takers use clues like dung, nests, and trails.

### **OCEANS** **Underwater Exploration**

Milestones include the only manned trip to the deepest point on Earth, the Sealab II habitat, and the discovery of the *Titanic*.

### **GEOGRAPHY** **Children at Work**

Across the globe, 215 million youngsters make pots, sell trinkets, toil in agriculture.



## ▲ **HEALTH**

### **Medical Marijuana**

It's legal in a dozen-plus states; a poll shows support for such laws in the rest of the U.S.

## **THE BIG IDEA**

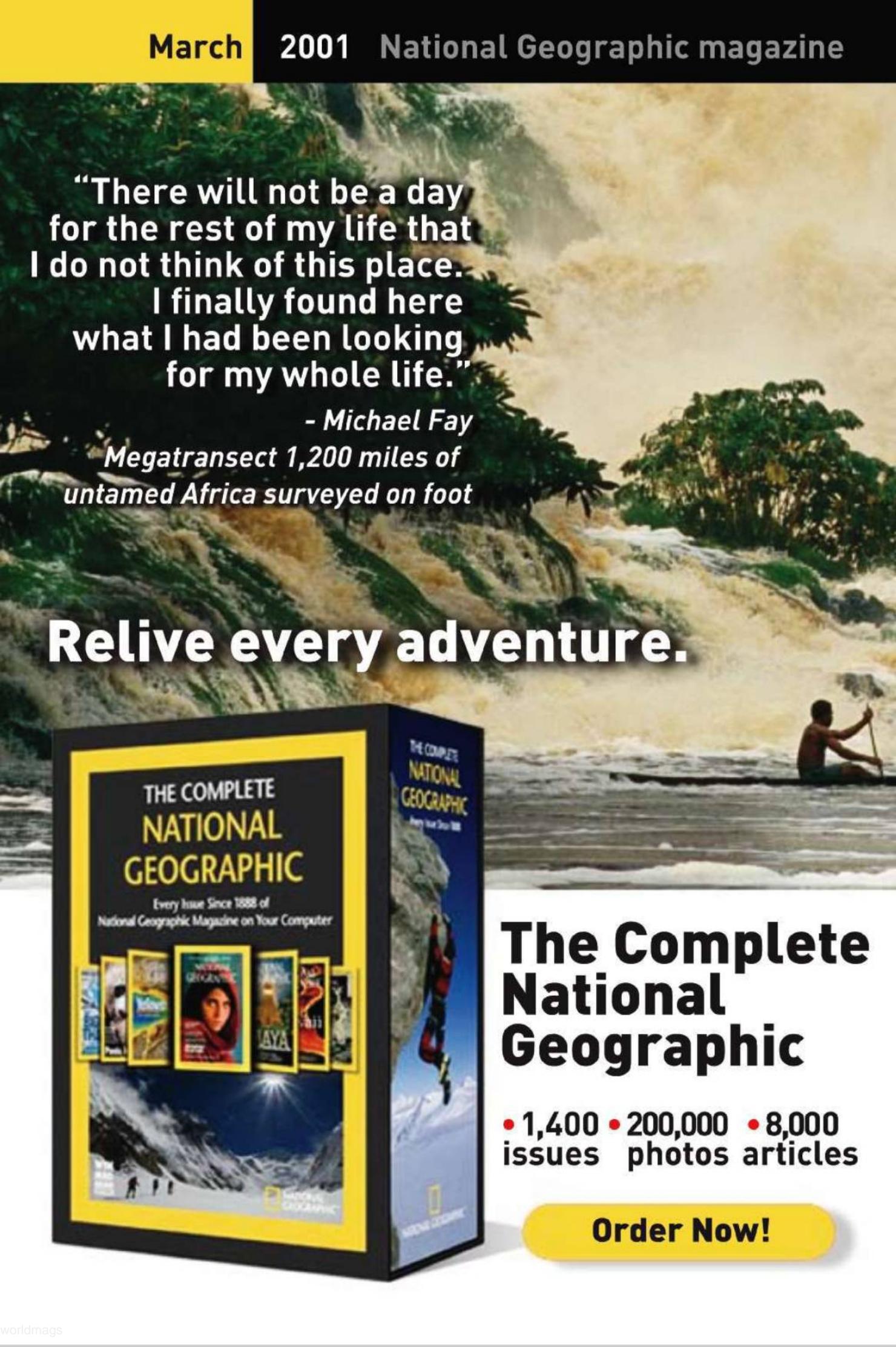
### **Little Packages**

#### **Do a Lot of Good**

Designers devise a low-cost infant warmer, a purifying straw, a paper asthma device, and more.



FOR SUBSCRIPTIONS AND GIFT MEMBERSHIPS, CONTACT CUSTOMER SERVICE AT [NGMSERVICE.COM](http://NGMSERVICE.COM), OR CALL 1-800-NGS-LINE (647-5463). OUTSIDE THE U.S. AND CANADA PLEASE CALL +1-813-979-6845.

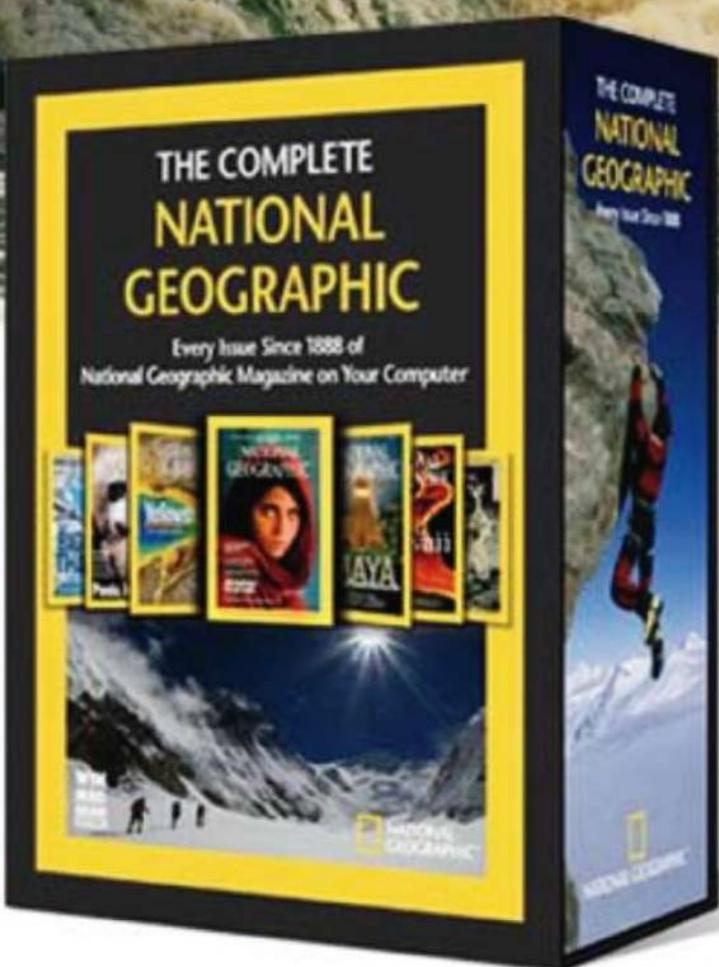


"There will not be a day  
for the rest of my life that  
I do not think of this place.  
I finally found here  
what I had been looking  
for my whole life."

- Michael Fay

*Megatransect 1,200 miles of  
untamed Africa surveyed on foot*

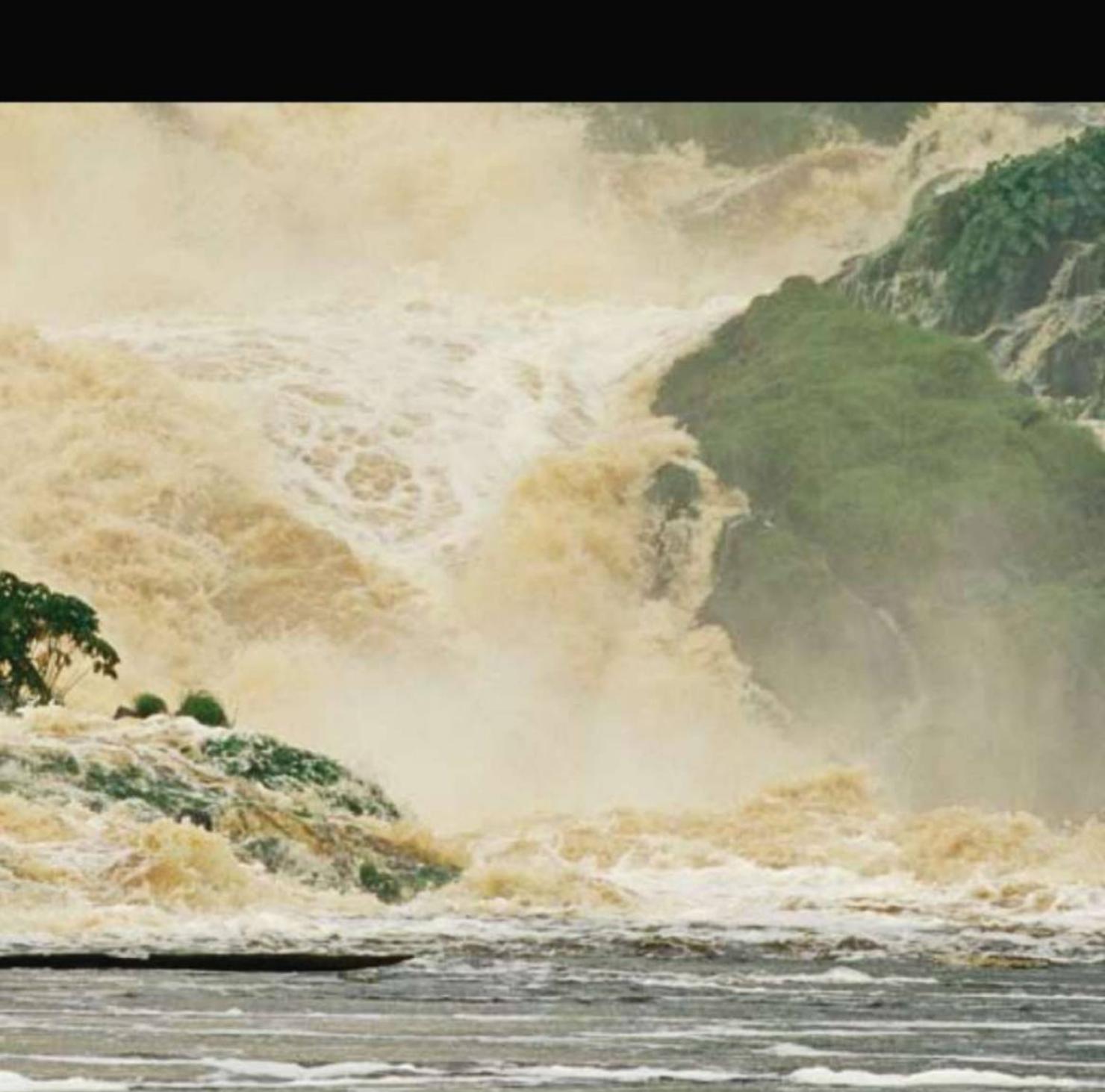
**Relive every adventure.**



## The Complete National Geographic

• 1,400 • 200,000 • 8,000  
issues photos articles

**Order Now!**



This definitive DVD-ROM collection of one of the world's most iconic magazines includes more than 120 years of articles, photographs, and maps, as they appeared in print. Browse electronic pages, search, zoom, scroll, and print in stunning high resolution as you relive thousands of amazing discoveries.

**[Click here to see a demo!](#)**

**120 page bonus book included!**



## EDITOR'S NOTE



Cape buffalo on the move in Botswana's Okavango Delta play a vital role in the region's ecosystem.

PHOTO: CHRIS JOHNS

**I awoke at sunrise** to a day on the Serengeti Plain that scarcely resembled the peaceful night before. The landscape that had been so quiet and empty was filled with thousands of wildebeests. They had followed the rain in search of grass, but this hardly seemed like an organized migration. It was anarchy in motion; wildebeests bucked and staggered in tight circles. They are comical-looking animals. African folklore says they were made from spare parts left from the creation of other beasts, but their role in sustaining the Serengeti is serious. Their migratory patterns are critical.

Bison once played a similar role on the North American prairie. In 1806 William Clark wrote: "I assended to the high Country and from an eminence I had a view of...a greater number of buffalow than I had ever seen before at one time. I must have seen near 20,000 of those animals feeding on this plain." When Clark journeyed west with Meriwether Lewis, tens of millions of bison lived on the grasslands, shaping vegetation, dispersing seeds, coexisting with burrowing owls and prairie dogs. By the late 1800s bison had been hunted nearly to extinction.

Fortunately, many other migratory spectacles survive. This month the world of migrations comes to life on the pages of our magazine, on the National Geographic Channel, and at [nationalgeographic.com](http://nationalgeographic.com). Our photographers and writers spent two years on the project. They were astonished and inspired by the determination and grace of these animals. I am sure you will be too.

A handwritten signature in black ink, appearing to read "Chris Johns".



▶ Video

**On the Move** This month the National Geographic Channel presents *Great Migrations*, a seven-part, global television event with unprecedented footage of millions of animals making their instinctive treks in the name of survival. Three years in the making, this program takes viewers across the globe, intimately capturing the often harrowing migrations of wildebeests, walruses, red crabs (above), and more. Then it takes us behind the scenes to see the advanced technology required to capture this spectacular, high-definition show of wildlife. Catch the first episode on November 7 at 8 p.m. ET; 7 p.m. PT.

Learn more about these and other Great Migrations projects at [natgeotv.com/migrations](http://natgeotv.com/migrations).

#### NAT GEO CHANNEL

*Great Migrations*, a seven-part series, begins November 7 at 8 p.m. ET.

#### NG BOOKS

*Great Migrations: Epic Animal Journeys* is in bookstores now. Prints of images from the book are available at [printsngs.com](http://printsngs.com).

#### PROGRAMS

National Geographic Live events include "The Making of Great Migrations," a screening and panel discussion, at Grosvenor Auditorium in Washington, D.C., on November 1. Photographer Joel Sartore will speak and show images of "Great American

Migrations" in Mesa, Arizona, on December 8, and in Chicago, Illinois, on December 14.

The National Geographic Museum in Washington, D.C., will feature "Great Migrations" photographs and video along the 17th Street portico beginning October 15.



**Learn more about these and other Great Migrations projects at [natgeotv.com/migrations](http://natgeotv.com/migrations).**

#### NAT GEO CHANNEL

*Great Migrations*, a seven-part series, begins November 7 at 8 p.m. ET.

#### NG BOOKS

*Great Migrations: Epic Animal Journeys* is in bookstores now. Prints of images from the book are available at [prints.ngs.com](http://prints.ngs.com).

#### PROGRAMS

National Geographic Live events include “The Making of Great Migrations,” a screening and panel discussion, at Grosvenor Auditorium in Washington, D.C., on November 1. Photographer Joel Sartore will speak and show images of “Great American

Migrations” in Mesa, Arizona, on December 8, and in Chicago, Illinois, on December 14.

The National Geographic Museum in Washington, D.C., will feature “Great Migrations” photographs and video along the 17th Street portico beginning October 15.

## LETTERS

### Evolutionary Road

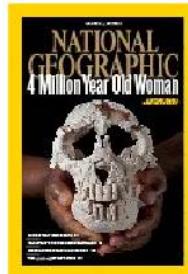
The title on the July 2010 cover reading "4-Million-Year-Old Woman" was a bit sensational and even misleading. A less interesting but more accurate title would have been "4-Million-Year-Old Female Hominid." The term "woman" refers to our own species and not to females of other species.

**BRIAN RITTER**  
Huntington Beach, California

This article is the best description of human evolution that I have ever read. Besides being understandable to a layperson (me), it illustrates the diligent work and dedication of the many archaeologists, paleontologists, and geologists who have devoted their lives and talents to this study. This article should elicit many responses from the creationists. Please publish some of these letters.

**RICHARD D. STACY**  
Montrose, Colorado

I thought you might find it interesting to see that your printer has messed up the July issue. Imagine my surprise when I cracked it open only to find the inside has articles from *Evolution Today* magazine. I was crestfallen as I discovered that my joyful romp through wonderful lands to learn about other people and places had been replaced by a scientific treatise. I can only hope that next month the printer (*Touch Text button to read more.*)

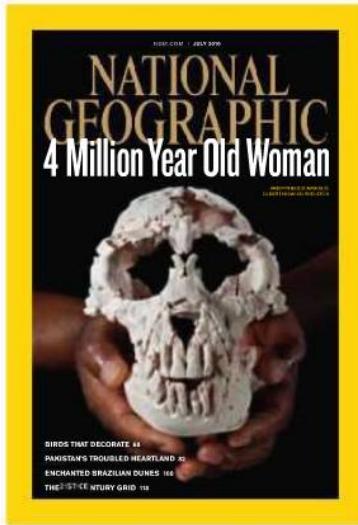


July 2010

A less interesting  
but more accurate  
title would have  
been "4-Million-  
Year-Old Female  
Hominid." The  
term "woman"  
refers to our own  
species, not to  
females of other  
species.

**Contact Us**  
**Email** ngsforum@ngm.com  
**Write** National Geographic Magazine, PO Box 98199, Washington, DC 20090-8199. Include name, address, and daytime telephone. Letters may be edited for clarity and length.

Text



July 2010

A less interesting  
but more accurate  
title would have  
been “4-Million-  
Year-Old Female  
Hominid.” The  
term “woman”  
refers to our own  
species, not to  
females of other  
species.

### Contact Us

**Email** ngsforum@ngm.com  
**Write** National Geographic  
Magazine, PO Box 98199,  
Washington, DC 20090-8199.  
Include name, address,  
and daytime telephone.  
Letters may be edited for  
clarity and length.



**EDITORS' CHOICE** **Paul Cotter** Charlotte, North Carolina

As his mother's health declined, Cotter, 52, thought "of all her small acts of kindness—like the tomato soup she made for me when I was a little boy." This shot was his way to say "farewell and to thank her for warming my heart."

... Slide Show

Selections from our editors





**Selections from our editors**





▶ Video  
Watch 70,000 still frames come to life (2:20).

## Rattlesnake Roundup

Do you know what they grow a lot of on the fields and ranchland outside Mangum, Oklahoma? Rattlesnakes.

They don't do it on purpose. Agricultural communities in the region have suffered population losses for years. When farms fell into decline, their fallow fields happened to provide a great habitat for rattlers, and they increased dramatically.

That's why, since 1966, a group of folks known as the Shortgrass Rattlesnake Association—one of them goes by the title "Fangmaster"—has thrown a kind of three-day annual party called the Mangum Rattlesnake Derby. Thousands of people come from all over to hunt, touch, eat, and have their pictures taken with rattlers. These visitors also bring a lot of much-needed revenue into this little prairie town.

But still photos don't really do Mangum justice. That's why I shot 70,000 frames with my still camera at this year's derby and then spent ten days splicing them into this video.

I hope you don't get too rattled.



## Rattlesnake Roundup

Do you know what they grow a lot of on the fields and ranchland outside Mangum, Oklahoma? Rattlesnakes.

They don't do it on purpose. Agricultural communities in the region have suffered population losses for years. When farms fell into decline, their fallow fields happened to provide a great habitat for rattlers, and they increased dramatically.

That's why, since 1966, a group of folks known as the Shortgrass Rattlesnake Association—one of them goes by the title "Fangmaster"—has thrown a kind of three-day annual party called the Mangum Rattlesnake Derby. Thousands of people come from all over to hunt, touch, eat, and have their pictures taken with rattlesnakes. These visitors also bring a lot of much needed revenue into this little prairie town.

But still photos don't really do Mangum justice. That's why I shot 70,000 frames with my still camera at this year's derby and then spent ten days splicing them into this video.

I hope you don't get too rattled.

**Scotland** Peering through glass, visitors at the Edinburgh Zoo regard—and are regarded by—Tibor, a captive-born Sumatran tiger. About 400 of this subspecies, the world's smallest tiger, live in the wild.

PHOTO: DAVID CHESKIN, PRESS ASSOCIATION/AP IMAGES



through glass, visitors at the Edinburgh Zoo regard—and are regarded by—Tibor, a Javan tiger. About 400 of this subspecies, the world's smallest tiger, live in the wild.

PHOTO: DAVID CHESKIN, PRESS ASSOCIATION/AP IMAGES



**Kenya** Aimed skyward from photos atop a train, the eyes of women pierce a rooftop landscape in Nairobi's Kibera slum. The display, part of a global art project, paid tribute to women from Africa, Brazil, India, and Cambodia.

PHOTO: JR/AGENCE VU/AURORA PHOTOS



rooftop landscape in Nairobi's Kibera  
Africa, Brazil, India, and Cambodia.

PHOTO: JR/AGENCE VU/AURORA PHOTOS



**United States** A 14-week-old male fawn gazes out a window at the Sarvey Wildlife Care Center. The Arlington, Washington, facility rehabs regional animals, including up to 30 orphaned or injured young deer each spring.

Order prints of National Geographic photos at [PrintsNGS.com](http://PrintsNGS.com).

PHOTO: ANNIE MARIE MUSSELMAN



Wildlife Care Center. The Arlington,  
injured young deer each spring.

**Order prints** of National Geographic  
photos at **PrintsNGS.com**.

PHOTO: ANNIE MARIE MUSSELMAN





Save 15% on  
Simply Beautiful Photography

**Buy prints  
starting at \$19.95**

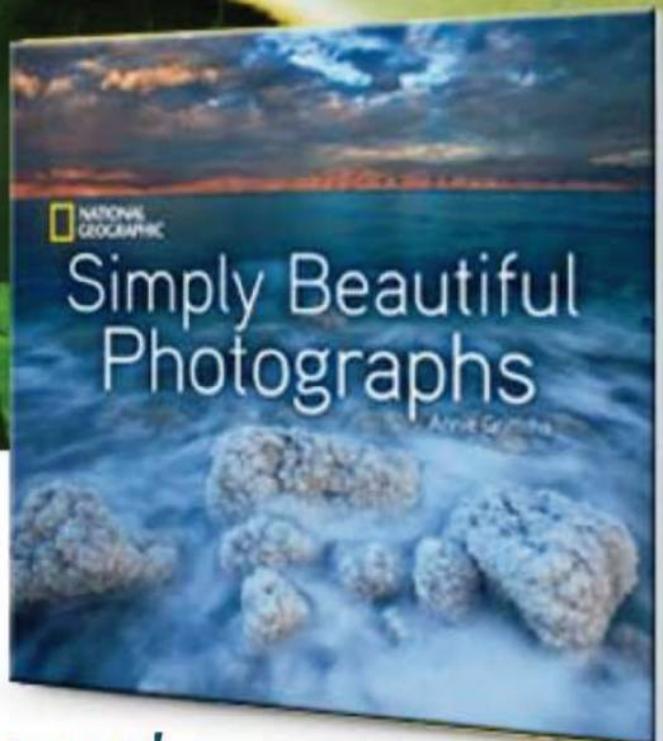
Save 15% use coupon code SB15

shop  
now!





Browse prints ➤  
featured in the  
upcoming book  
*Simply Beautiful Photographs*



# CONSERVATION



In Rwanda's Volcanoes National Park, a young silverback gorilla sits in solitude.

PHOTO: MATTIAS KLUM. NGM MAPS

NATIONAL GEOGRAPHIC NOVEMBER 2010



## Tracking Gorillas

When counting mountain gorillas, try to avoid the animals themselves. That's the task primatologist Martha Robbins and 71 others took while conducting their latest census of the endangered species. "We don't want to encounter unhabituated gorillas," she explains, "because it is stressful for them." Rather than seeking out individuals, the team followed clues such as dung, nests, and trails to estimate gorilla numbers in the volcanic Virunga Mountains of equatorial Africa—one of only two places where the great apes live.

At last count, in 2006, some 680 were estimated to remain in that area and Uganda's Bwindi Impenetrable National Park. The 2010 Virunga census, followed by a Bwindi survey next year, will tell how the gorillas are faring now, after years of poaching, deforestation, and political unrest. Also expected, thanks to fecal-sample analysis: fresh insights into the elusive creatures' genetic diversity and overall health. —Catherine Barker



The Virunga range is home to one of just two mountain gorilla populations that remain today.

## G E O G R A P H Y

**No Minor Issue** Across the globe, kids can be seen hawking trinkets and swabbing down tea shops. But these are only the most visible of the world's 215 million child laborers. A new report by the United Nations' International Labour Organization (ILO) says that 60 percent of them toil unseen in the agricultural sector, often for little or no pay. And the isolation of those in domestic work, says Human Rights Watch, can increase the odds of their exploitation.

Between 2004 and 2008 the number of child laborers decreased by seven million; Asia and Latin America, particularly Brazil, led the way, thanks to government initiatives. Yet South Asia remains home to the most in the world; one in four sub-Saharan kids is still classified as a child laborer; and the economic crisis could stall progress by feeding demand for cheap labor.

Going forward, the ILO urges a global commitment to compulsory education—by abolishing school fees, for instance—and government pacts with organized workers. It estimates that spending \$140 billion in sub-Saharan Africa over 20 years could produce up to \$724 billion in benefits, including massive health-care savings as children cease doing hazardous work. “The world can afford this,” the report concludes. Call it a minor investment with a major payoff. —Noy Thrupkaew

Child laborers include those under 12 doing any jobs other than household chores. Long hours, underground work, and heavy-machinery use are termed hazardous.

\*EXCLUDES AUSTRALIA, NEW ZEALAND, JAPAN, AND PARTS OF CENTRAL ASIA. PHOTO: G. M. B. AKASH, PANOS PICTURES. GRAPHIC: MINA LIU. SOURCE: INTERNATIONAL LABOUR ORGANIZATION





Liyakot Ali, 13, makes cooking pots in a Bangladesh factory.

### Child labor estimates by region 2008

#### Asia; the Pacific\*

Child laborers  
114 million

Children in  
hazardous  
work  
48 million

#### Sub-Saharan Africa

65 million  
39 million

Latin  
America; the  
Caribbean  
14 million  
9 million

Other  
22 million  
19 million

# OCEANS

## MILESTONES

**A Century Beneath the Sea** In 1960 a bathyscaphe took two men to the deepest point on Earth. In 2010 that manned descent to the Mariana Trench—still unmatched—won co-pilot Don Walsh the Hubbard Medal, National Geographic’s top honor for research and discovery. Yet it remains just a single, vital drop in an age of ocean exploration.

The secrets of the deep have emerged from research done far below the waves—and from far above them. Oceanographer Walter Munk deems the satellite TOPEX/Poseidon’s 13-year mapping of the sea surface, showing how currents affect climate, “the most successful ocean experiment of all times.”

What will the next century of marine science reveal? Maritime historian Helen Rozwadowski says that although most scientists think robotics are the way forward, some idealists still call for a Sealab-style colonization of the sea. Either way, she says, environmental concerns will likely influence all future ocean exploration—“unless somehow the dreamers get our attention again.” —*Jeremy Berlin*



GRAPHIC: OLIVER UBERTI, NGM STAFF. ART: JASON LEE

NATIONAL GEOGRAPHIC NOVEMBER 2010

**830 miles above Earth**  
The TOPEX/Poseidon satellite begins mapping the surface of the sea.

## IN OCEAN EXPLORATION

1934      1943      1960 1965      1977      1985      1992      2010

1934

1943

1960 1965

1977

1985

1992

2010



210 feet

3,028 feet

205 feet

8,000 feet

12,600 feet



16,000 feet  
and above

**Sea surface** Acoustic exploration of the ocean starts when Reginald Fessenden tests an oscillator that will be used to locate icebergs.

**205 feet** Sealab II, an underwater habitat, is lowered off the coast of California.

**210 feet** Jacques Cousteau and Émile Gagnan develop and test modern scuba.

**3,028 feet** Manned exploration of the deep begins in earnest when William Beebe and Otis Barton are lowered in a tethered bathysphere.

**8,000 feet** Hydrothermal vents and chemosynthetic animals are discovered in the Galápagos Rift.

**12,600 feet** Robert Ballard, later a Hubbard Medal winner, and his team find the wreck of the *Titanic*.



35,800 feet

**16,000 feet and above** The decade-long Census of Marine Life unveils hundreds of new species.

**35,800 feet** Co-piloted by Don Walsh and Jacques Piccard, the *Trieste* reaches the bottom of the ocean—the Pacific's Mariana Trench.

**Reefer Referral** Here's a sign that the times are a-changin': Nearly three out of four Americans say they favor legalizing medical marijuana in their state, according to a 2010 Pew Research Center survey. And 41 percent think all marijuana should be legal, up from 35 percent in 2008 and 12 percent in a 1969 Gallup poll. Pot has become political in recent years. This summer Congress let the District of Columbia join a dozen-plus states with medical-marijuana laws on the books. Proponents say legalization will create tax revenues and save money on enforcement. And the American College of Physicians and the American Medical Association have endorsed research on the plant's makeup. Issued for glaucoma and to help cancer patients deal with chemotherapy, cannabinoids like THC are also being probed for anticancer properties.

All of which means aging hippies aren't alone. The Pew poll found backing for medical marijuana across the political spectrum and all age groups—a clear sign that tolerance is growing. —*Alex Dominguez*





Medical marijuana like this is federally supplied to only a handful of patients.

## Approval in the U.S. for medical marijuana 2010

- In favor
- Opposed
- Don't know

A minimum of 61% of all groups are in favor.

### Gender

Men 100%

Women

### Ethnicity

White

Black

Hispanic

### Age

18-29

30-49

50-64

65+

### Education

College graduate

Some college

High school or less

### Political affiliation

Republican

Democrat

Independent

# Big Ideas

## Little Packages

Designers are creating innovative, affordable products as solutions to problems all over the world.



SOME OF THE OBJECTS ON THESE PAGES ARE COURTESY OF THE EXHIBIT "DESIGN FOR THE OTHER 90%" BY THE SMITHSONIAN COOPER-HEWITT, NATIONAL DESIGN MUSEUM.

PHOTO: REBECCA HALE, NGM STAFF



MORE

### Infant Warmer

Around 19 million low-birth-weight babies are born every year in developing countries. Unable to regulate their body temperatures, many die. The Embrace helps to warm vulnerable infants (a special pouch slips into the back of the bag to provide hours of safe heat) while allowing for nursing and cuddling.

**Developed by** Jane Chen, Linus Liang, Naganand Murty, Rahul Panicker

**Website** [embraceglobal.org](http://embraceglobal.org)

**Launch country** India

**CAN GOOD DESIGN SAVE THE WORLD?** It just might, one novel idea at a time. Designers have always dreamed up innovative goods for those who could afford such things: New offerings include solar roof tiles, electric motorcycles, and more. Now, sparked by programs such as the Entrepreneurial Design for Extreme Affordability course at Stanford University's Institute of Design (source for several items in this article), some are taking a look at the concerns of people in developing countries as well. Keeping local culture in mind, designers are creating products to meet communities' particular needs. It turns out that even the most pressing problems, from health care to potable water, can have affordable—and beautifully designed—solutions. —Margaret G. Zackowitz

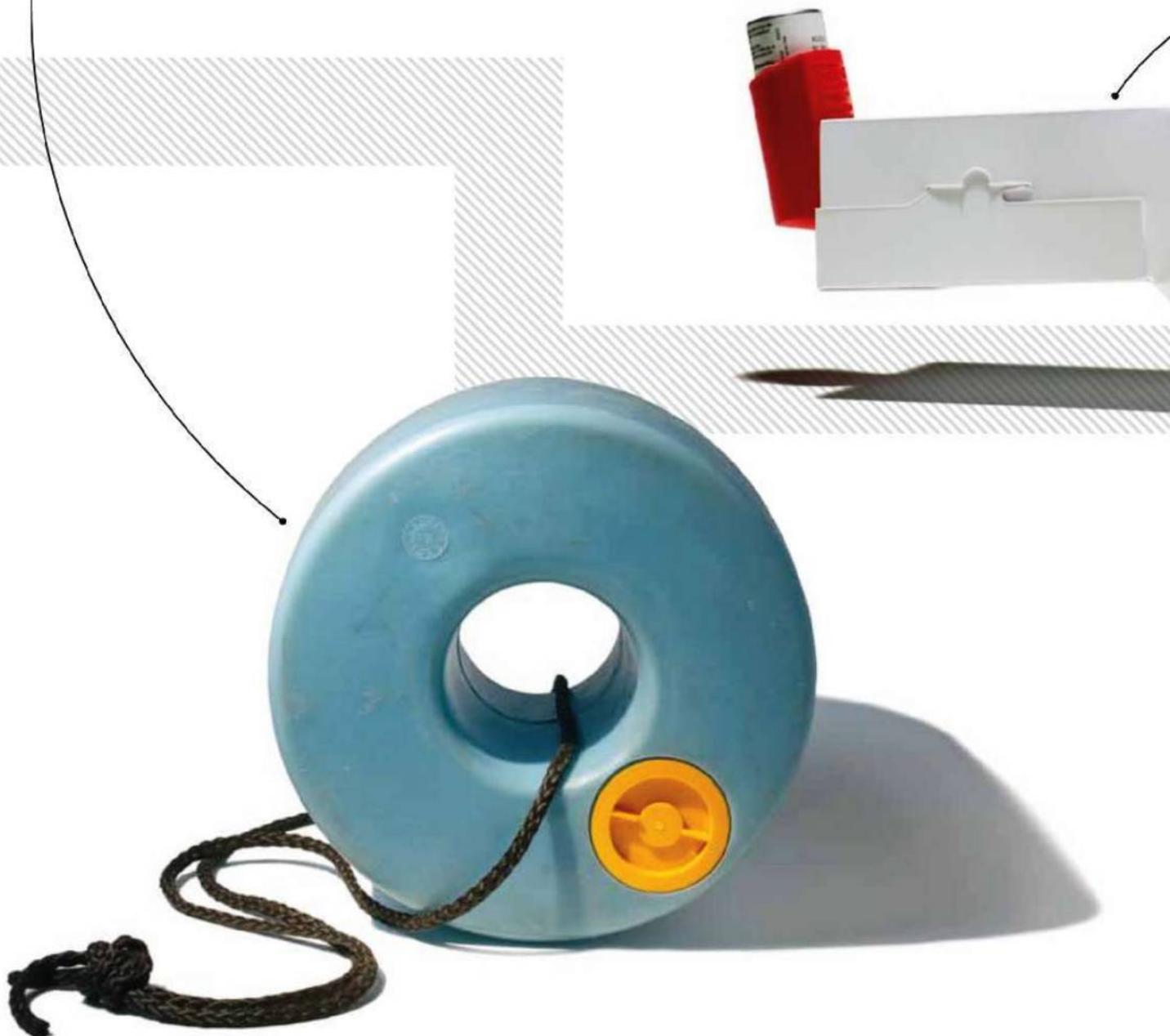
## Water Container

In impoverished rural areas, clean water is often miles away from the people who need it, leaving them susceptible to waterborne diseases. The sturdy Q Drum holds 13 gallons in a rolling container that eases the burden of transporting safe, potable water—a task that falls mostly to women and children.

**Developed by** P. J. and J. P. S. Hendrikse

**Website** [qdrum.co.za](http://qdrum.co.za)

**Launch country** South Africa



MORE

## Purifying Straw

Some 900 million people lack access to safe drinking water. Sipping through the LifeStraw filters surface water on-site, reducing the transmission of bacteria and viruses. Thousands of ten-inch LifeStraws were donated to Haiti after this year's earthquake. Each filters about 160 gallons; a new, shorter model, nearly 265.

**Developed by** Vestergaard Frandsen

**Website** [lifestraw.com](http://lifestraw.com)

**Launch country** Kenya



## Asthma Device

Young asthmatics often can't coordinate breathing with the aerosol puff dispensed by inhalers. The folded-paper Respira "spacer" traps medication around the mouth so that it can be inhaled. Conventional spacers can run \$20 or more—a prohibitive cost in the developing world, where asthma rates are rising. Respira costs about a dollar.

**Developed by** Eric Green, Santiago Ocejo, Barry Wohl

**Website** [respiradesign.org](http://respiradesign.org)

**Launch country** Mexico

PHOTOS: RENEE COMET (LIFESTRAW, Q DRUM);  
MARK THIESSEN, NGM STAFF (INHALER)

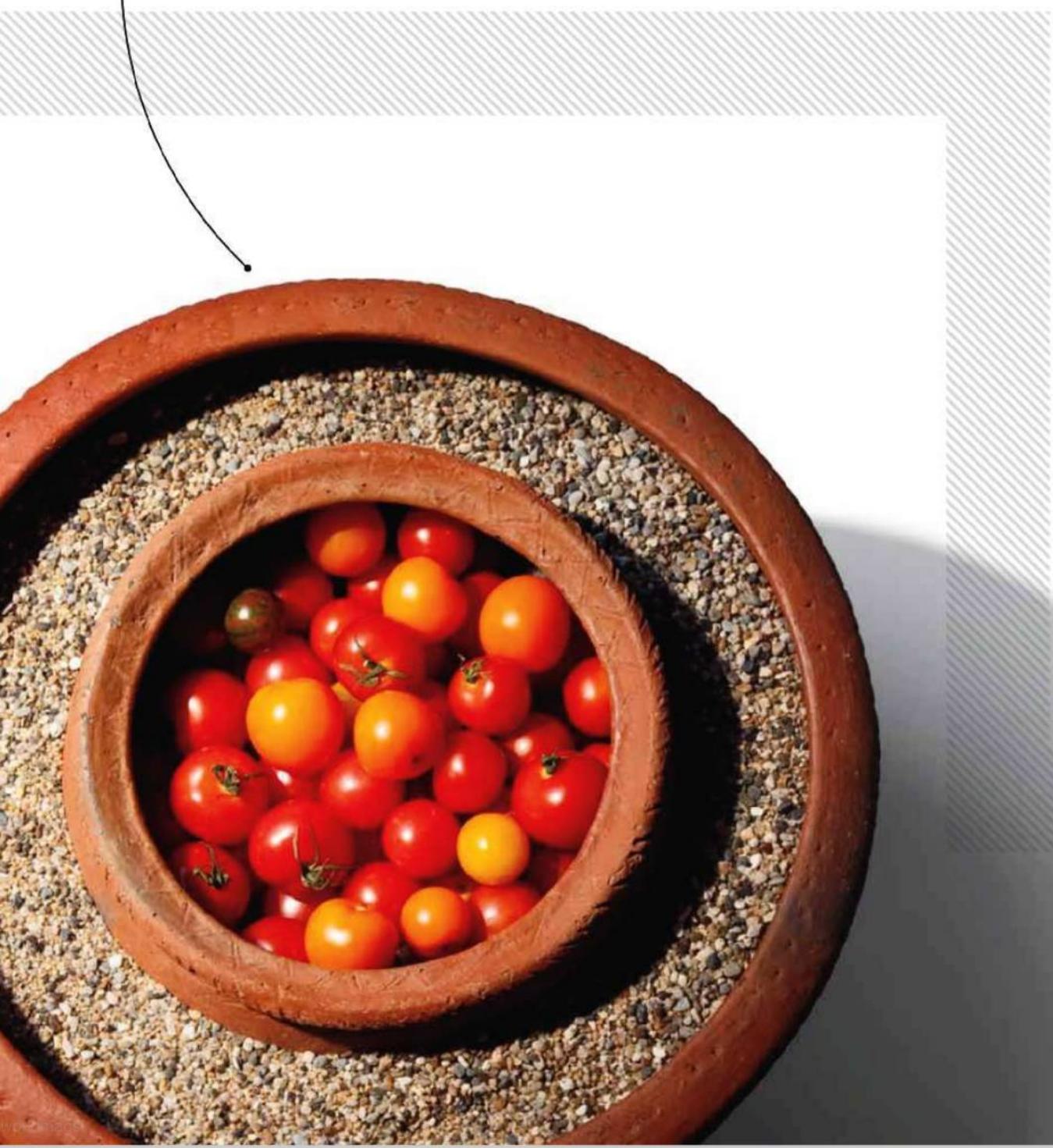
### **Portable Clay Refrigerator**

Building upon an ancient food-storage technique, the pot-in-pot system uses evaporation from a layer of wet sand between two nesting pots to help extend the life of farmers' goods. Tomatoes can last weeks instead of just days, meaning more fresh produce at the market and more income for farmers.

**Developed by** Mohammed Bah Abba

**Website** none available

**Launch country** Nigeria



MORE >

## Sugarcane Charcoal

Burning wood and dung, the main fuel sources for many in the developing world, has contributed to deforestation and respiratory ailments. Not only do briquettes made from crushed sugarcane stalks make use of an abundant local resource, they burn more cleanly and allow residents to start a charcoal business for less than \$50.

**Developed by** MIT D-Lab

**Contact** [d-lab.mit.edu/resources](http://d-lab.mit.edu/resources)

**Launch country** Haiti



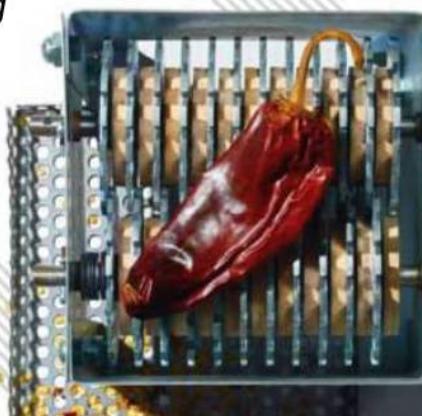
## Chili Grinder

Ethiopian women have for centuries crushed chili peppers by hand—a time-consuming, painful way to add value to a staple spice. The Pepper Eater mills chilies four times faster, creating uniform flakes and sparing hands from chili-oil burns.

**Developed by** Samuel Hamner,  
Scott Sadlon

**Website** [thepeppereater.org](http://thepeppereater.org)

**Launch country** Ethiopia



PHOTOS: MARK THIESSEN, NGM STAFF (GRINDER);  
RENEE COMET (CHARCOAL, COOLER)



### Solar Roof Tiles

Solé Power Tiles may look like blue versions of the clay roof tiles traditionally used in sunny climes, but they're made of a durable polymer—and they're actually curved photovoltaic solar panels, creating enough energy daily to cut a typical American home's electric bill by 70 percent or more.

**Developed by** SRS Energy

**Website** [srsenergy.com](http://srsenergy.com)

**Launch country** U.S.

### Solar Light

Hazardous kerosene lamps are the only source of lighting for millions of people all over the world. The solar-powered MightyLight is safer, cleaner, and more versatile: It can be hung on a wall, placed on a tabletop, or carried. It also lasts longer—its LED technology is good for up to 30 years of use.

**Developed by** Amit Chugh,

Matthew Scott

**Website** [cosmosignite.com](http://cosmosignite.com)

**Launch country** India



MORE >

### Electric Motorcycle

Made mostly from recycled materials, the Enertia "refuels" at either 110-volt or 220-volt electrical sockets. It travels at up to 60 miles an hour, emits no exhaust, and goes more than 40 miles between charges. The faster Empulse, with longer battery life, is due out in 2011.

**Developed by** Brian Wismann

**Website** [brammo.com](http://brammo.com)

**Launch country** U.S.



PHOTOS: MARK THIESSEN, NGM STAFF (TILE, LIGHT);  
PAUL WELLMAN (MOTORCYCLE)



### **Solar Wi-Fi Streetlight**

The StarSight system provides a series of pylons that use solar panels to power streetlamps, a Wi-Fi box for wireless Internet access, and if desired, closed-circuit TVs for security surveillance. The result: an integrated system of electricity and communication, plus better street lighting, which has been shown to help reduce crime.

**Developed by** Kolam Partnership Ltd.

**Website** [starsightproject.com](http://starsightproject.com)

**Launch countries** Nigeria, South Africa, Turkey

## Affordable Laptops

The One Laptop per Child project aims to educate children in remote parts of the world. Governments purchase the computers, each equipped with Wi-Fi “rabbit ears” and e-book mode, for schools. Uruguay has already distributed some 400,000 laptops, with another 90,000 on order. A tablet version is due in 2012.

**Developed by** Nicholas Negroponte,  
Rodrigo Arborela Halaby

**Website** [laptop.org](http://laptop.org)

**Launch country** Brazil



## Hearing-Aid Recharger

The high cost of imported batteries can render hearing aids unaffordable for people in developing nations. This solar recharger accepts specially fitted hearing aids and standard rechargeable batteries, making hearing help less costly. More than 6,000 units are already in use in Africa, South and Central America, and Asia.

**Developed by** Godisa Technologies Trust  
**Website** none available  
**Launch country** Botswana

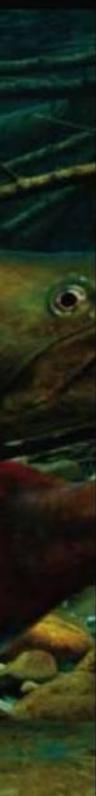


# Great M



In the summer bull trout forge 50 miles upstream from Lake Koocanusa to spawn in the Wigwam River drainage in British Columbia.

# migrations



WHAT IS IT THAT MAKES ANIMAL  
MIGRATION SUCH A MAGNIFICENT  
SPECTACLE FOR THE EYE AND THE MIND?

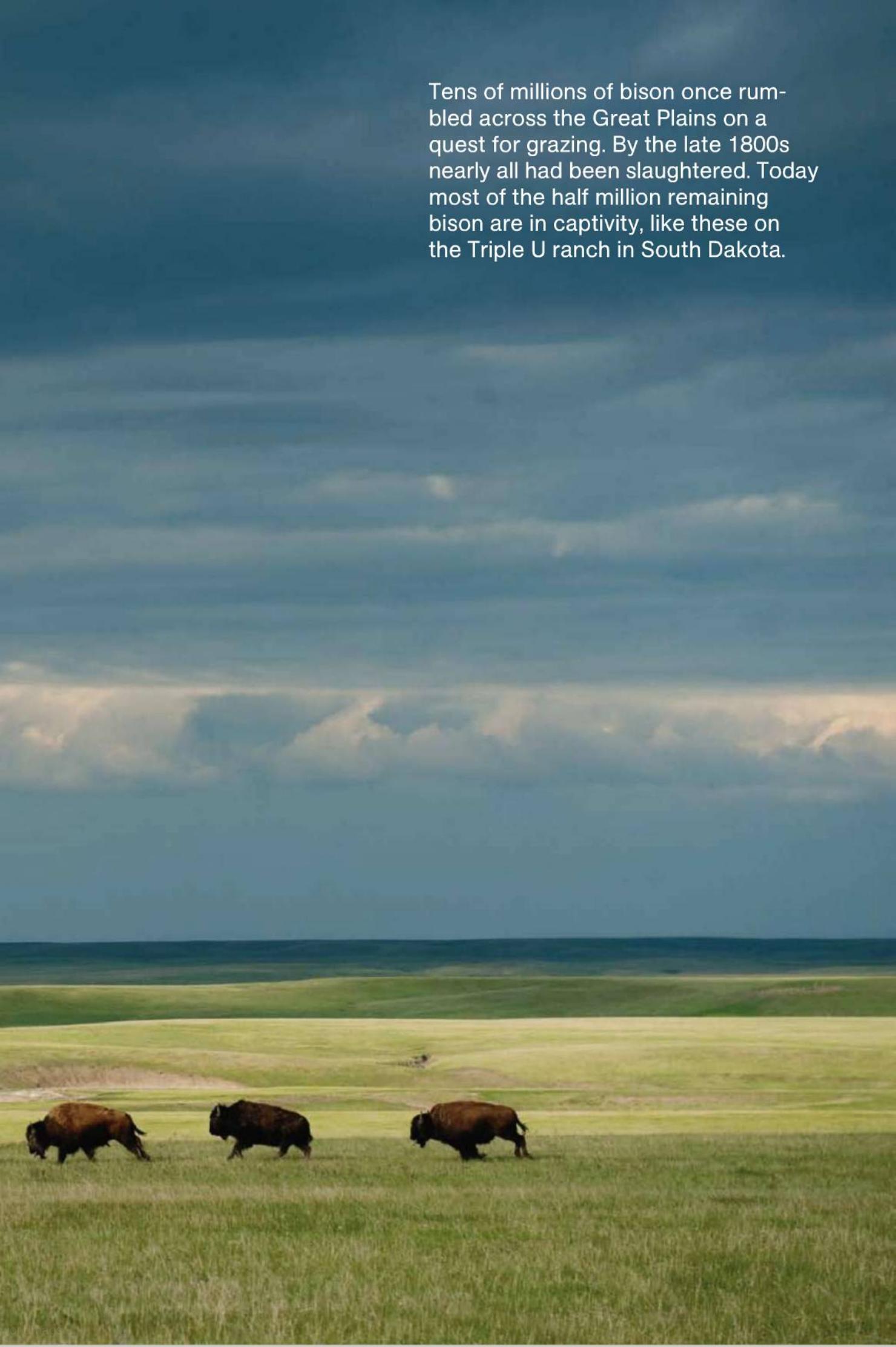
Is it the sheer abundance of wildlife in motion? Is it the steep odds to be overcome? Is it the amazing feats of precise navigation? The answer is all of the above. But there's another reason why the long-distance journeys of wildebeests, sandhill cranes, monarch butterflies, sea turtles, and so many other species inspire our awe. One biologist has noted the "undistractibility" of migrating animals. A non-scientist, risking anthropomorphism, might say: Yes, they have a sense of larger purpose.

Half a million sandhill cranes pause on the Platte River in Nebraska to fatten up on corn waste, worms, and other food in nearby fields. The break occurs on their spring flight from Mexico and the southern U.S. to breeding grounds in the far north.









Tens of millions of bison once rumbled across the Great Plains on a quest for grazing. By the late 1800s nearly all had been slaughtered. Today most of the half million remaining bison are in captivity, like these on the Triple U ranch in South Dakota.

Millions of monarch butterflies travel to ancestral winter roosts in Mexico's shrinking mountain fir forests. Surfing winds from southern Canada and the northern U.S., they travel thousands of miles, taking directional cues from the sun.





BY DAVID QUAMMEN  
PHOTOGRAPHS BY JOEL SARTORE

# Animal migration is a phenomenon far grander and more patterned than animal movement. It represents collective travel with long-deferred rewards.

It suggests premeditation and epic willfulness, codified as inherited instinct. A biologist named Hugh Dingle, striving to understand the essence, has identified five characteristics that apply, in varying degrees and combinations, to all migrations. They are prolonged movements that carry animals outside familiar habitats; they tend to be linear, not zigzaggy; they involve special behaviors of preparation (such as overfeeding) and arrival; they demand special allocations of energy. And one more: Migrating animals maintain a fervid attentiveness to the greater mission, which keeps them undistracted by temptations and (Touch Text button to read more.)



Worn like a backpack, a tiny plastic geolocator helps map bobolinks on their 12,000-mile flight from the grasslands and rice fields of Bolivia and Argentina to North America, including a stopover along the Platte River in Nebraska (above). If a male bobolink hears another male calling in his territory, he'll chase the intruder away. So researchers who want to tag males with geolocators catch them by playing a recording of a male's call, which to human ears sounds like the chirps of R2-D2, the robot of *Star Wars* fame.

*Contributing Writer David Quammen is the author of 11 books, including The Reluctant Mr. Darwin. Nebraska-based Joel Sartore specializes in covering biodiversity. This is his 30th story for the magazine.*

Text



Worn like a backpack, a tiny plastic geolocator helps map bobolinks on their 12,000-mile flight from the grasslands and rice fields of Bolivia and Argentina to North America, including a stopover along the Platte River in Nebraska (above). If a male bobolink hears another male calling in his territory, he'll chase the intruder away. So researchers who want to tag males with geolocators catch them by playing a recording of a male's call, which to human ears sounds like the chirps of R2-D2, the robot of *Star Wars* fame.

*Contributing Writer David Quammen is the author of 11 books, including *The Reluctant Mr. Darwin*. Nebraska-based Joel Sartore specializes in covering biodiversity. This is his 30th story for the magazine.*



Mountain goats in Montana's Glacier National Park may travel thousands of feet a day—vertically. This one descended a sheer rock wall to lick salt and other exposed minerals. Nutrients that aren't as available during the long winter may trigger the hankering.







# Incredible Journeys

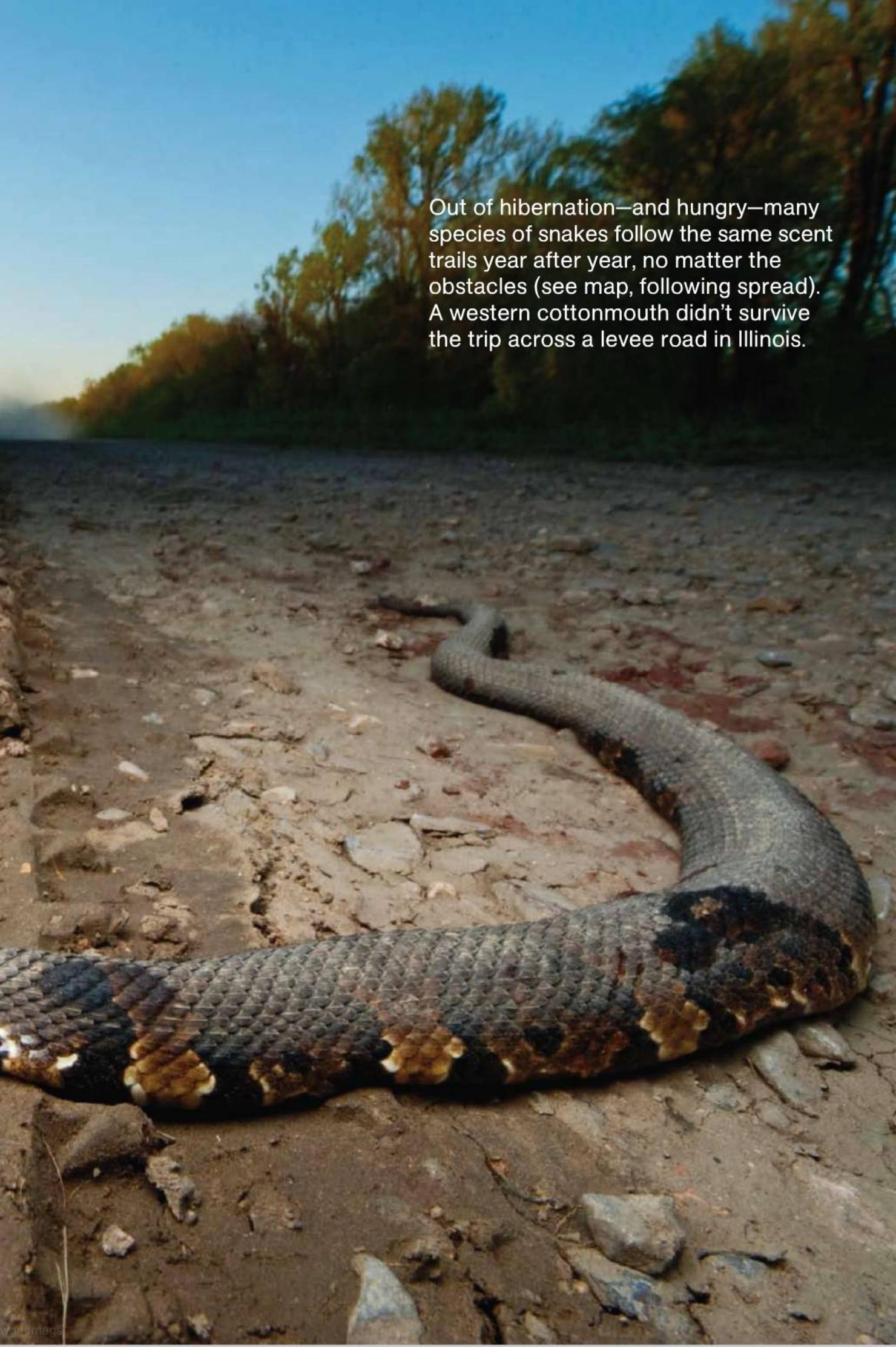
## Migration routes

- ↔ Sandhill crane
- ↔ Pronghorn
- ↔ Monarch butterfly
- ↔ Mexican free-tailed bat

0 mi  
0 km 500

WILLIAM E. McNULTY AND LISA R. RITTER,  
NGM STAFF. SOURCES: ROWE SANCTUARY,  
NATIONAL AUDUBON SOCIETY (CRANE);  
MICHAEL SUITOR, UNIVERSITY OF CALGARY  
(PRONGHORN); MONARCH BUTTERFLY  
FUND AND MONARCH WATCH (BUTTERFLY);  
GARY MCCRACKEN, UNIVERSITY OF  
TENNESSEE (BAT)



A large snake, likely a cottonmouth, is coiled on a rocky riverbank. The snake has dark, mottled patterns on its body. The background shows a river with trees on the opposite bank under a clear blue sky.

Out of hibernation—and hungry—many species of snakes follow the same scent trails year after year, no matter the obstacles (see map, following spread). A western cottonmouth didn't survive the trip across a levee road in Illinois.

## WINTER DEN

A satellite-style map showing the South Saskatchewan River flowing through a hilly, light-colored terrain. A thick red arrow points along the river's course from the southern end towards the northern end of the visible area.

## **Female prairie rattlesnake summer migration routes**

Route of  
the snake  
named E

## **IRRIGATED CROP FIELDS**





Rattlesnakes on spring feeding forays from underground winter dens near Medicine Hat, Alberta, encounter a landscape altered by human activity.

NGM MAPS. SOURCE: DENNIS JØRGENSEN, WWF.  
SATELLITE IMAGE: GEOEYE



JOEL SARTORE WITH COLE SARTORE



Mexican free-tailed bats spiral out of Eckert James River Bat Cave Preserve in Texas at dusk. The bats are hungry for pests like corn earworm moths—nutrition to keep milk flowing for their pups. Every spring millions of free-tails return to this cave.



These 32 bats and four songbirds represent an average yearly toll for each of the 23 turbines at a Pennsylvania wind farm. Raptors like the red-tailed hawk (left) are rare victims.





Horse Hollow wind farm near Abilene, Texas, one of the world's largest, has more than 400 turbines. The turbines' spinning blades cause a drop in air pressure, which can kill bats.

JOEL SARTORE WITH PETER COLTMAN





Pronghorn run fast—upwards of 60 miles an hour—but they rarely jump fences. Some ranchers plan to raise the lowest fence strands so pronghorn, like these near Medicine Hat, Alberta, can more easily slip under during their winter migration.

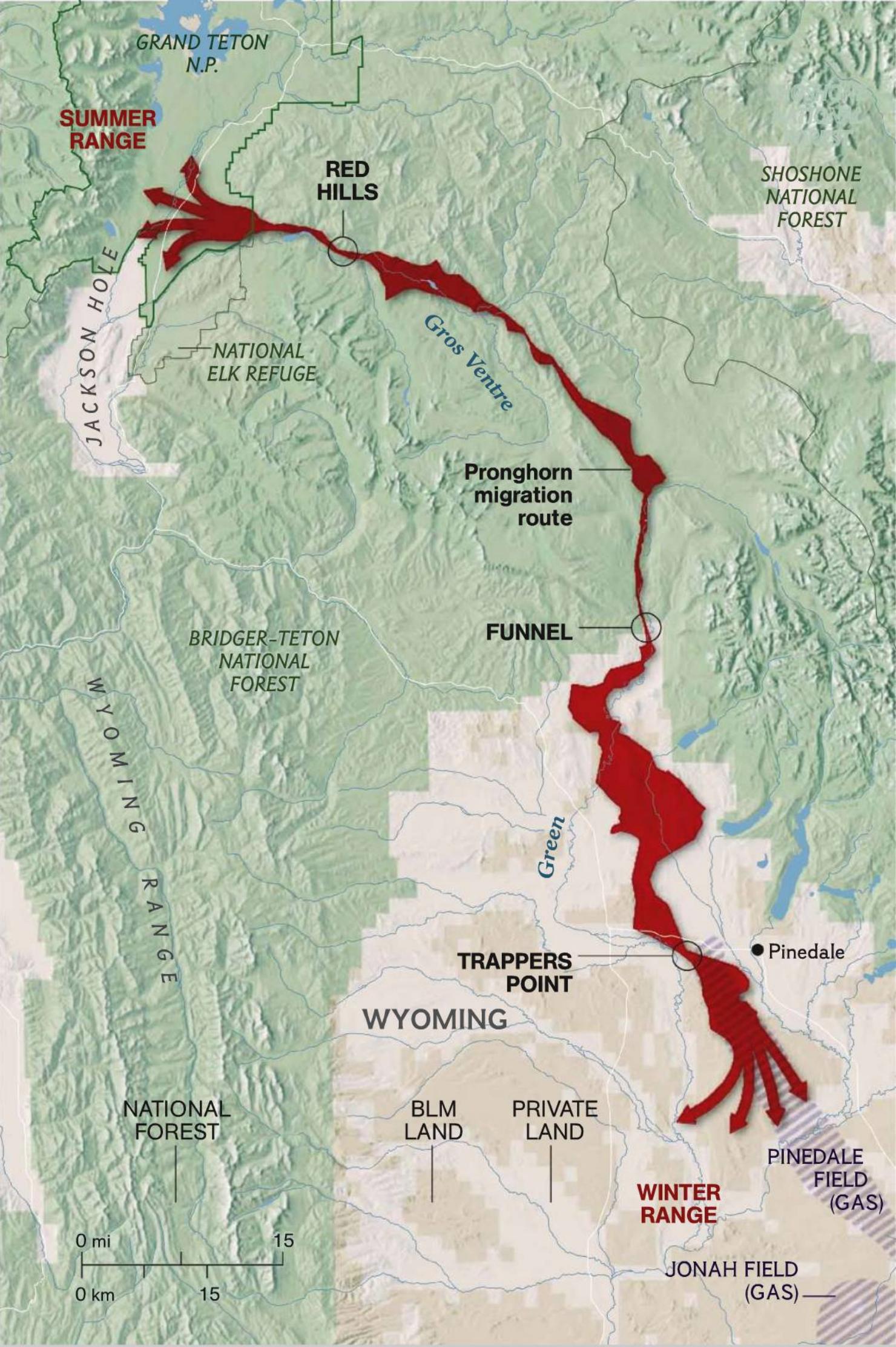


JOEL SARTORE WITH NATHAN WILLIAMSON



Gas drilling projects, such as Jonah Field, impede pronghorn migration, and new homes restrict corridors to no more than a few hundred yards wide in places.







Pronghorn migrating between summer and winter ranges in northwestern Wyoming negotiate steep valleys, forested mountainsides, and a gantlet of man-made intrusions.

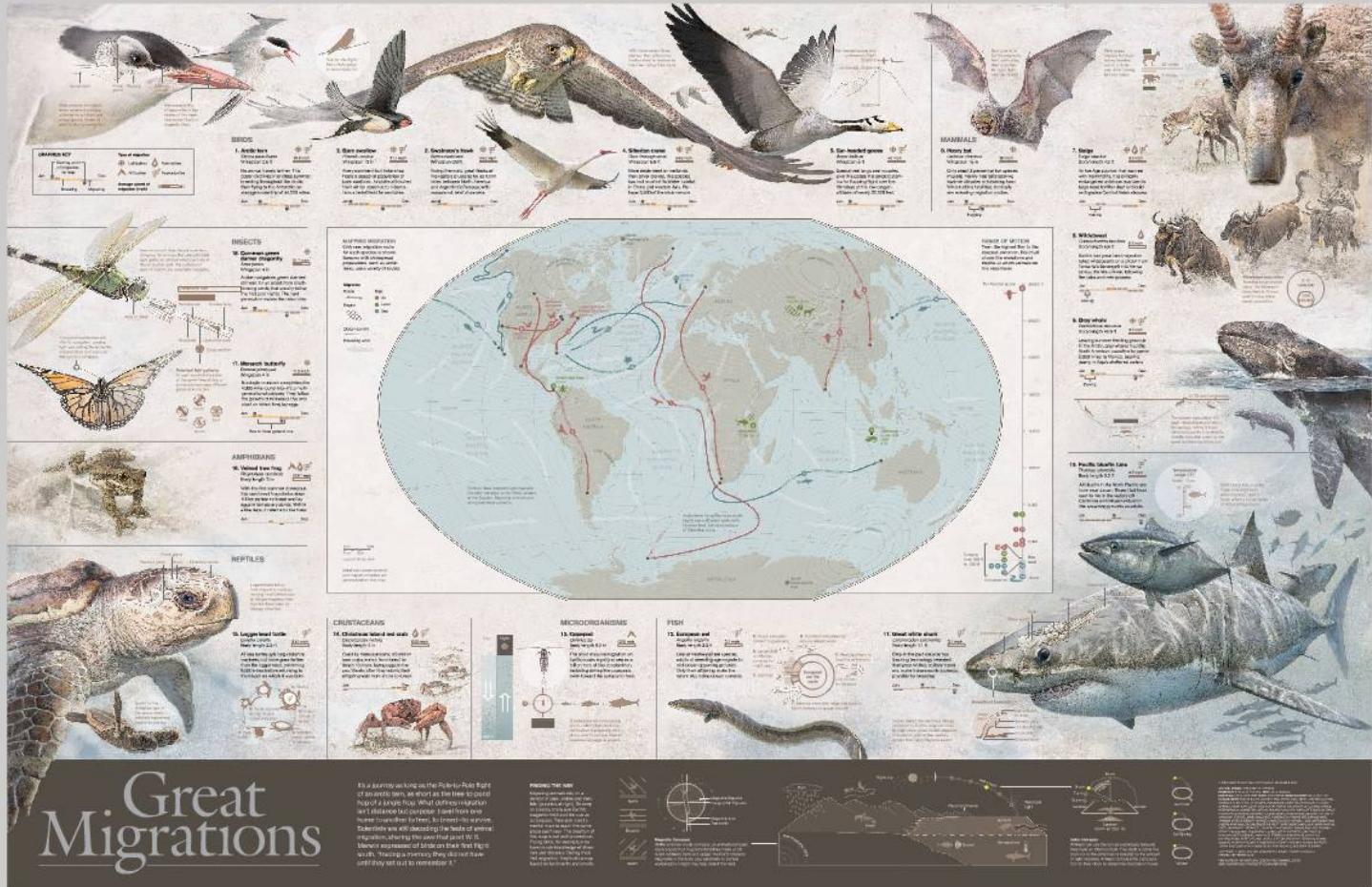
NGM MAPS. SOURCE: ANDRA TOIVOLA, WILDLIFE CONSERVATION SOCIETY

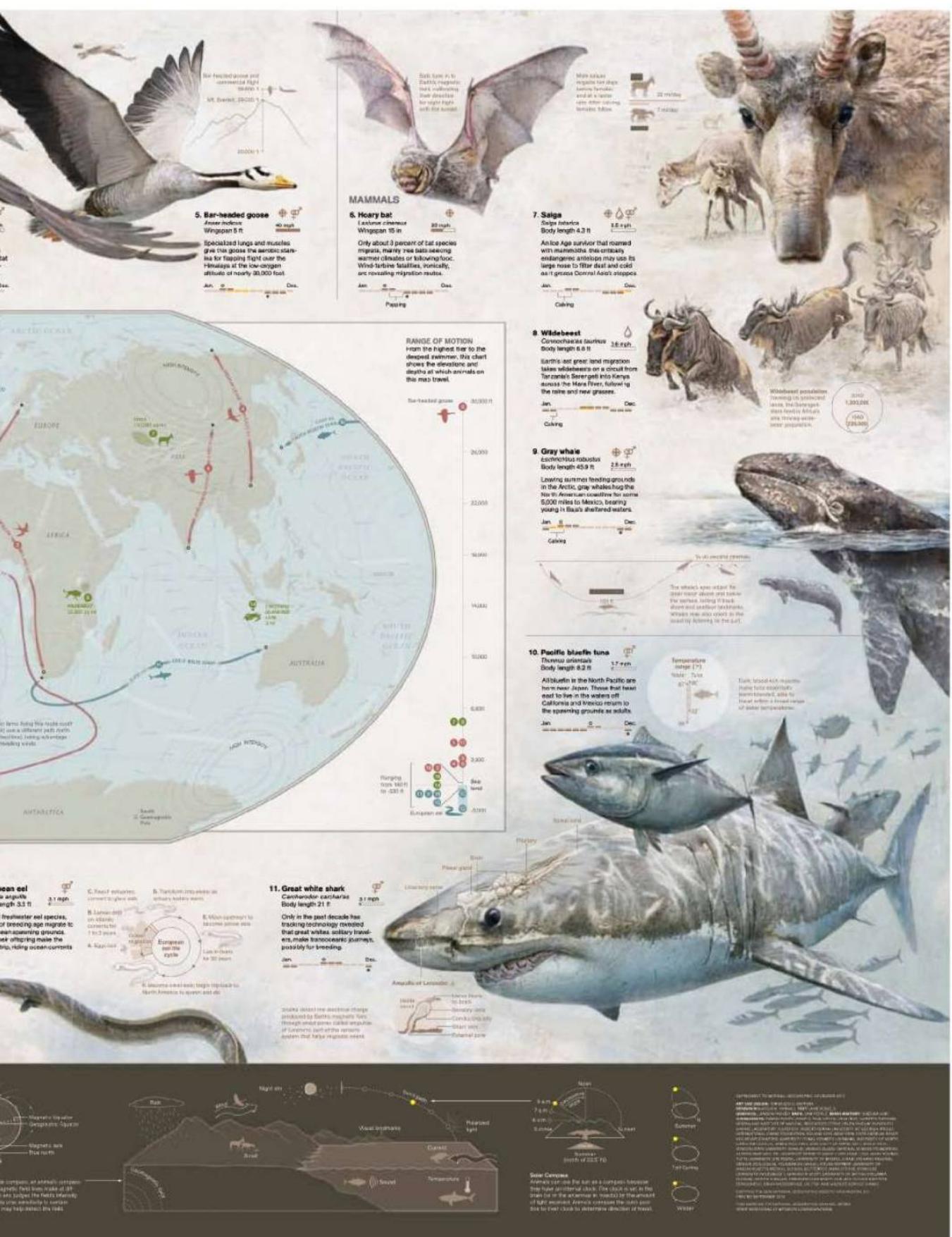
A border wall along the lower Rio Grande in Texas divides nations as well as habitats, hindering essential daily movements of animals in the area. Bobcats would normally cross the border to find mates or catch dinner—this one caught a rat. The wall also blocks the daily rounds of ocelots, another member of the cat family.

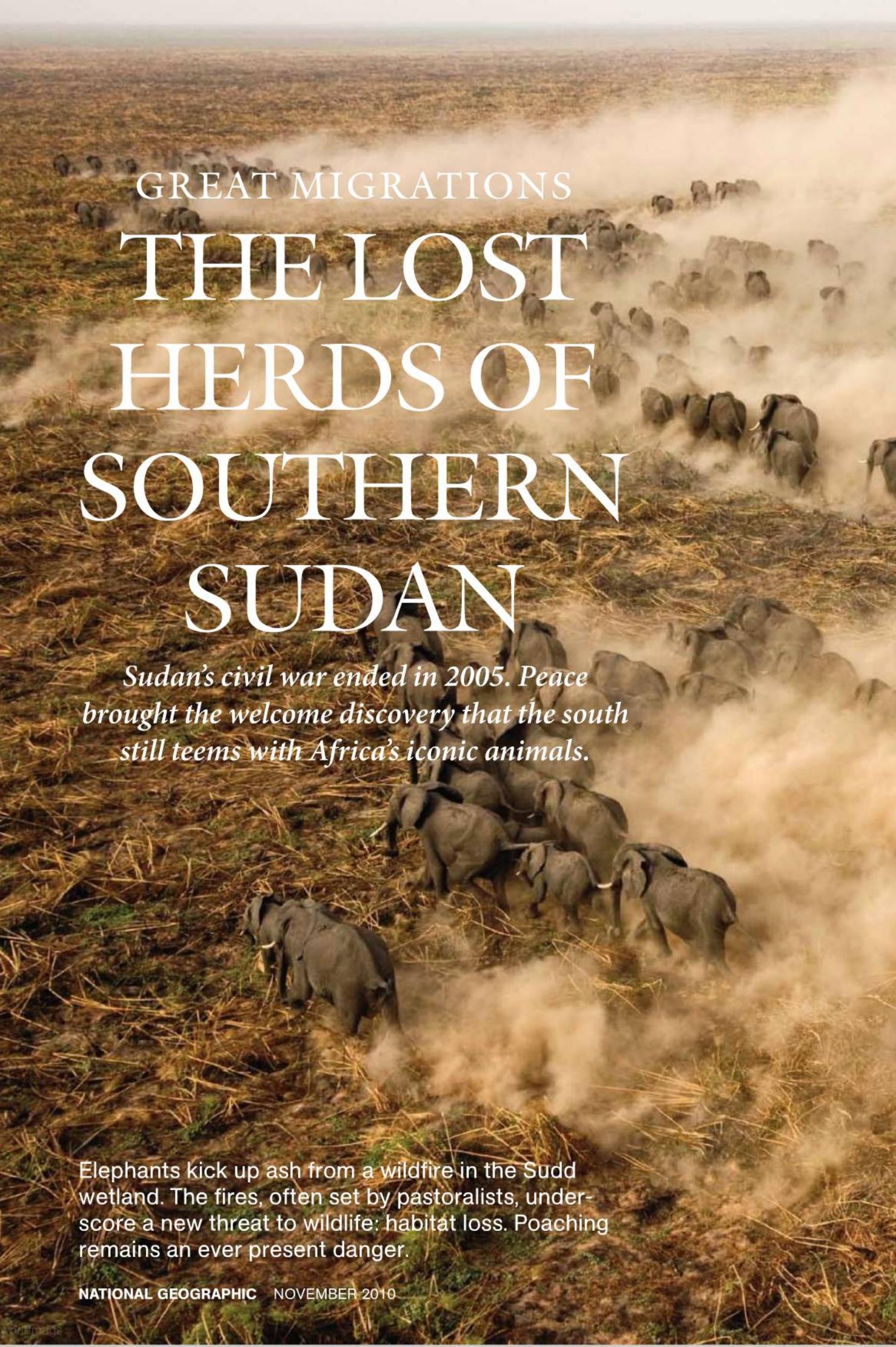
JOEL SARTORE, WITH MITCH STERNBERG, JENNIFER LOWRY,  
AND NAGHMA MALIK, ALL U.S. FISH AND WILDLIFE SERVICE











# GREAT MIGRATIONS THE LOST HERDS OF SOUTHERN SUDAN

*Sudan's civil war ended in 2005. Peace brought the welcome discovery that the south still teems with Africa's iconic animals.*

Elephants kick up ash from a wildfire in the Sudd wetland. The fires, often set by pastoralists, underscore a new threat to wildlife: habitat loss. Poaching remains an ever present danger.





NATIONAL GEOGRAPHIC NOVEMBER 2010



Thousands of white-eared kob race in the shadow of a Wildlife Conservation Society survey plane in a park east of Bor. The seasonal migration of animals in southern Sudan is a spectacle to rival the flow of animals across Tanzania's Serengeti Plain.

BY MATTHEW TEAGUE

PHOTOGRAPHS BY GEORGE STEINMETZ

**N**ot long ago in Juba, in an old colonial building with cracked walls and fitful electricity, two former military men—Lt. Gen. Fraser Tong and Maj. Gen. Philip Chol Majak—were explaining the situation.

"Organized gangs, maybe 50 men, are coming in on horseback," Tong said. "They're targeting elephants and the bigger ungulates. They dry the meat and keep the ivory and transport it on camelback."

Tong is the undersecretary for wildlife in semi-autonomous southern Sudan, based in Juba, the capital. Majak is a senior staffer, a wildlife field commander whose army unit was famous for shooting down MiG jets with shoulder-fired missiles during Sudan's latest civil war, which began in 1983. A cease-fire ended that conflict five years ago, but now Majak is fighting a new war. "We have to protect these animals," he said.

There's urgency (*Touch Text button to read more.*)

*Matthew Teague wrote about the Uygurs of China's Xinjiang region last December. George Steinmetz began his photographic career in Africa 30 years ago.*



Wildlife experts struggle to place a GPS satellite collar on a tranquilized bull elephant in Boma National Park. A Wildlife Conservation Society project aims to track elephant migration to and from Ethiopia.

Text



Wildlife experts struggle to place a GPS satellite collar on a tranquilized bull elephant in Boma National Park. A Wildlife Conservation Society project aims to track elephant migration to and from Ethiopia.

# Abundant Animals, High Risk

## Migration routes

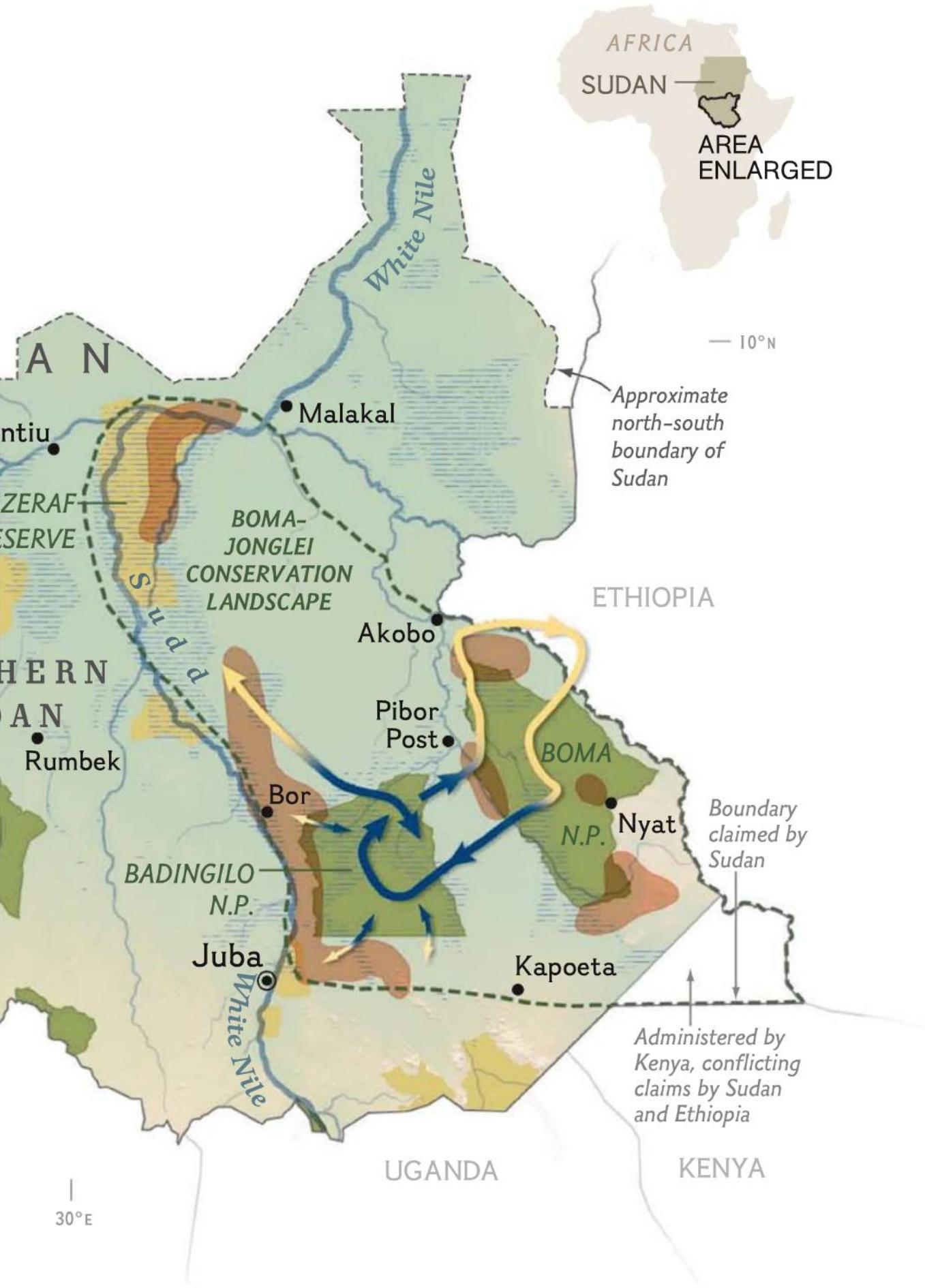
Tiang, white-eared kob

Dry season  
Nov. to Apr.

Mongalla gazelle, reedbuck

Wet  
May to Oct.







NATIONAL GEOGRAPHIC NOVEMBER 2010



A floating fishing camp drifts in the Sudd, one of Africa's largest wetlands—more than 20,000 square miles in the rainy season. The scale of this place makes it difficult for wildlife authorities to patrol and enforce hunting and fishing laws.



NATIONAL GEOGRAPHIC NOVEMBER 2010



As dry season peaks, people at a Dinka fishing camp hunt anything they can find, like this Nile lechwe laid out on a hippo skin. The meat is dried on wooden racks. Authorities tend to overlook subsistence hunting. To evade capture, commercial poachers hide in vast stretches of wilderness.



NATIONAL GEOGRAPHIC NOVEMBER 2010



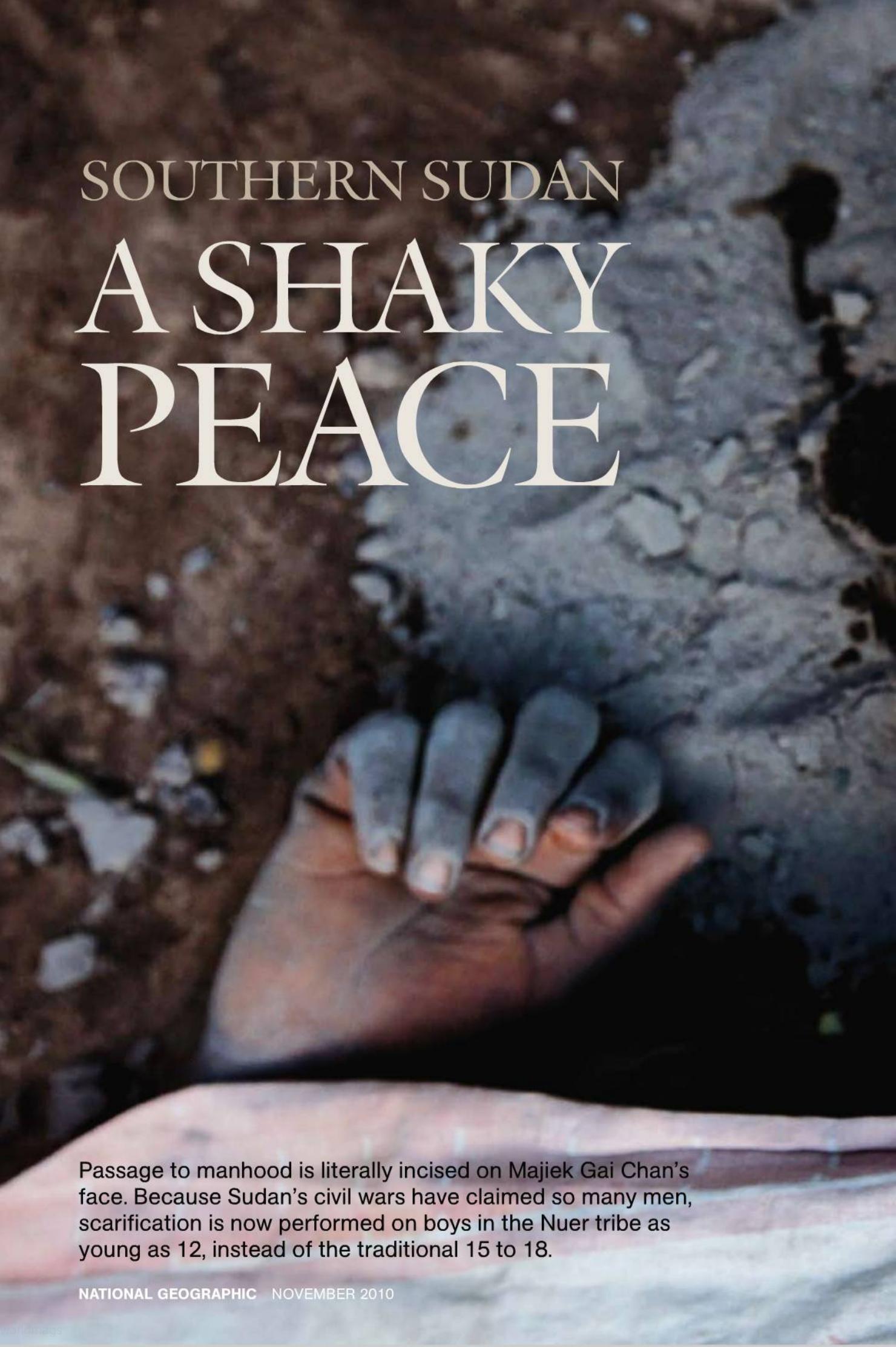
A herd of buffalo navigates grasslands in the Sudd, which contains about 10,000 of the animals. Before 1983, when Sudan descended again into civil war, 60,000 buffalo roamed Southern National Park, some 200 miles from here. Today, WCS aerial surveys of the park have sighted none.



NATIONAL GEOGRAPHIC NOVEMBER 2010



Masses of vegetation float like giant lily pads on the ever changing surface of the Sudd. Southern Sudan's virtually impenetrable wetlands provided sanctuary for wildlife during 25 years of civil war.



# SOUTHERN SUDAN A SHAKY PEACE

Passage to manhood is literally incised on Majiek Gai Chan's face. Because Sudan's civil wars have claimed so many men, scarification is now performed on boys in the Nuer tribe as young as 12, instead of the traditional 15 to 18.







In September 2009 Nuer tribesmen attacked the Dinka village of Duk Padiet. The death toll of at least 167 included civilians as well as soldiers, adding to the lives lost in regional violence despite a 2005 treaty ending Sudan's most recent civil war. A UN helicopter evacuated the wounded.



NATIONAL GEOGRAPHIC NOVEMBER 2010



Cattle—foundation of the Dinka economy—speckle a floodplain in a camp near a branch of the Nile during the dry season. The animals are corralled at night to defend them against cattle raiders, then taken out to graze during the day.



NATIONAL GEOGRAPHIC NOVEMBER 2010



Villagers abandoned Nyiek during the civil war. Years later, after the peace treaty, they returned to find oil drillers had moved in—so they moved up the road. Little of the oil revenue trickles down: The village lacks both electricity and running water.

BY MATTHEW TEAGUE

PHOTOGRAPHS BY GEORGE STEINMETZ

**O**ne day some years ago, before the latest civil war began in earnest, a Sudanese boy named Logocho peeked into the entry of his family's grass hut. His father sprang out and grabbed him, and then, with an older boy, pinned him in the dirt.

A strange boy, Logocho. Above him, his father's shoulders and chest rippled with welted tribal scars. A Morse code of dots and dashes crossed the father's face and forehead, signaling to any potential cattle raiders—the Dinka, the Nuer—that he, as a Murle, would defend his stock with spear, knife, fists, and teeth.

But his son showed no interest in the old ways. When other children, including his own brother, underwent an early Murle rite of passage, he ran and hid in the grass. Now his body, smooth as a calf's, trembled and arched in the dust. Nothing marked him as Murle.

More alarming, the nine-year-old boy showed no interest in cattle. Like his brother, Logocho crouched to suckle the udders (*Touch Text button to read more.*)



The trademark hat worn by Salva Kiir, president of semiautonomous southern Sudan, was a gift from President George W. Bush during a summit. A former battlefield commander who has led the south since 2005, Kiir will guide his country through a referendum next year, when a vote for full independence is expected.

Text



The trademark hat worn by Salva Kiir, president of semiautonomous southern Sudan, was a gift from President George W. Bush during a summit. A former battlefield commander who has led the south since 2005, Kiir will guide his country through a referendum next year, when a vote for full independence is expected.

# Oil Divide

Under the 2005 Comprehensive Peace Agreement between the south and the north, the south was to receive 50 percent of the profits from oil produced there. The treaty also gave southerners the right to hold a referendum on independence in 2011. If they vote to secede, will Khartoum let them—and the oil—go?

## Oil infrastructure

### Refinery

All of Sudan's oil refineries are in the north.

### Oil fields

The south produces 65 percent of Sudan's oil.

## Oil blocks

### Blocks producing oil

### Blocks not producing oil

Multinational consortiums buy extraction rights in oil blocks. Discrepancies in reported production (below) feed the south's concern that the north does not share oil revenue as agreed under the peace treaty.

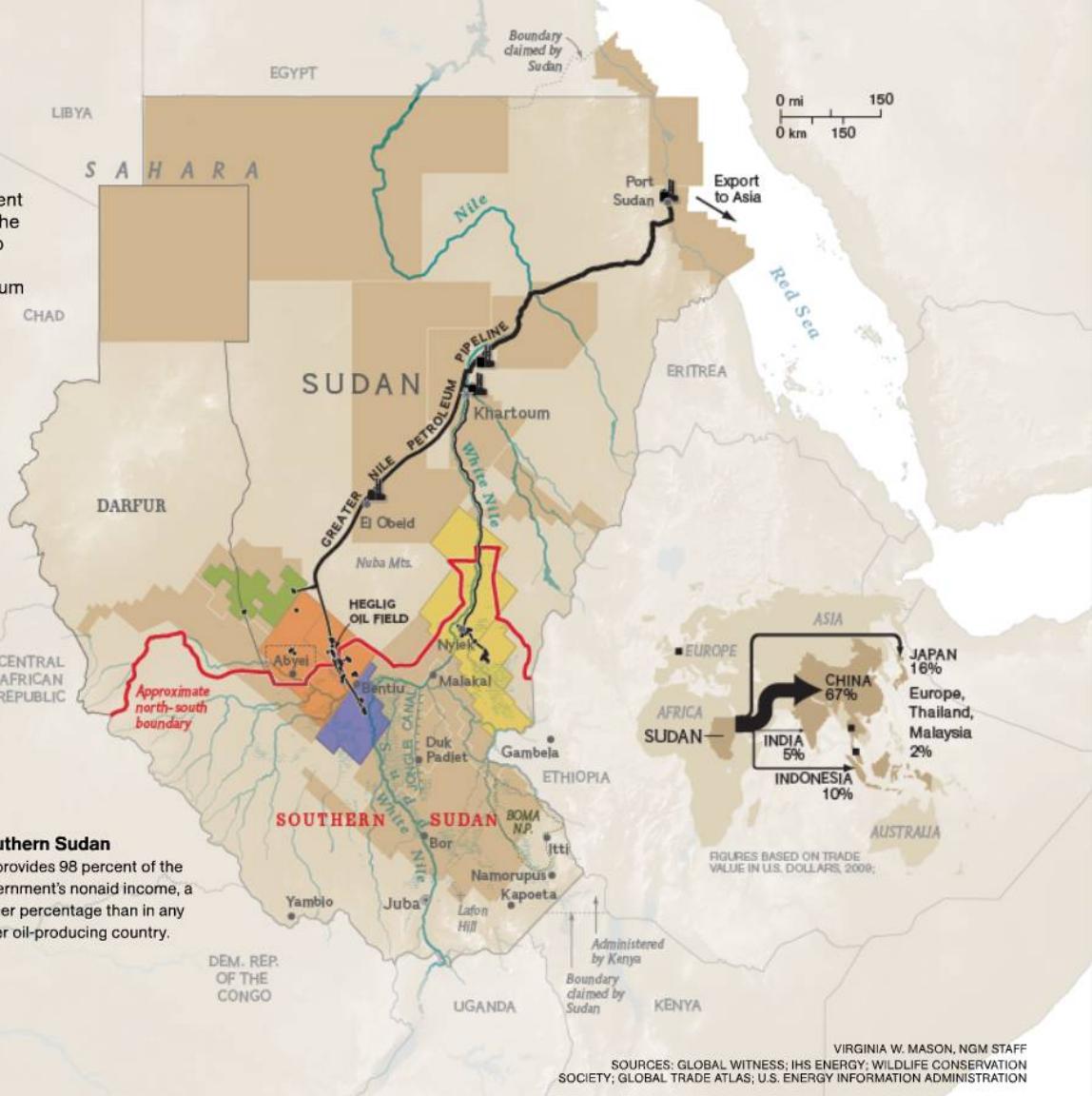
## Oil production by block

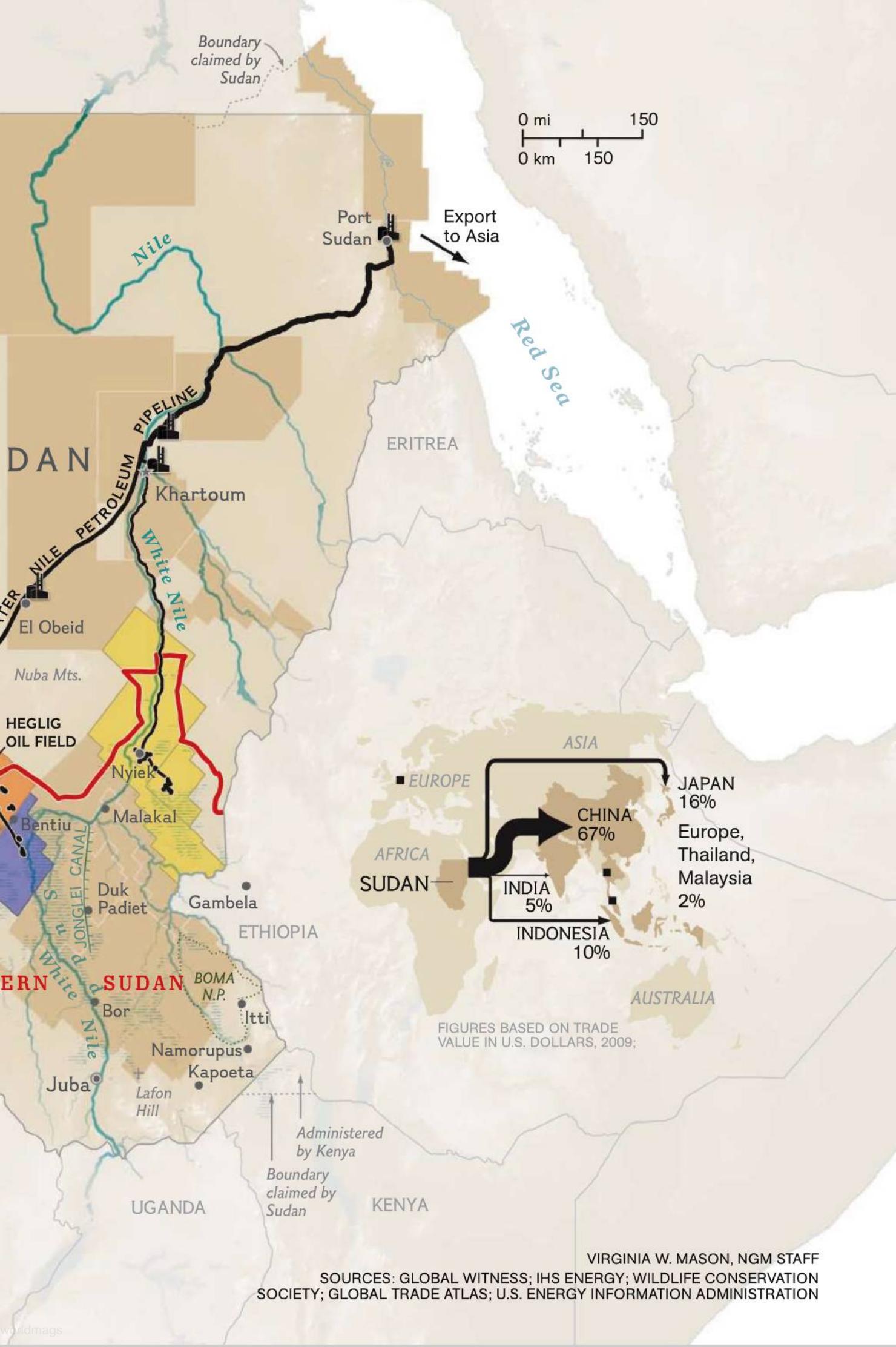
### Reported by government

### By oil company



worldmag







NATIONAL GEOGRAPHIC NOVEMBER 2010



Women's work in the Toposa village of Namorupus includes making a granary roof from natural materials like grass. Farming falls mainly to women, while caring for and herding cattle to seasonal grazing grounds falls to men.



The newly welded framework for a shop takes to the road in Bentiu. The town sits amid the oil fields of Unity State, governed by the south since the end of the civil war. Without a pipeline of its own, the south must send its oil through a northern pipeline to a port on the Red Sea.



*Sudan finds itself wobbling between the possibility of lasting peace and the threat of fresh violence. In 2011 the people of southern Sudan will vote on whether to secede.*





With a constant stream of hucksters and workers lured by the promise of jobs and peace, Juba winks at all comers like a gold rush town. Having grown threefold since 2005, the unruly capital of southern Sudan can barely provide basic city services for its residents.





Under a southern Sudanese civilian-disarmament program, soldiers from the Sudan People's Liberation Army found 762 rifles and one 60-millimeter mortar in and around the village of Kuda. Since last November, 35,000 weapons have been collected in the south.



NATIONAL GEOGRAPHIC NOVEMBER 2010



As rain greens the land in Burgilo County, men from the Pari tribe will bring their cows home from seasonal grazing camps eight miles away. Until soldiers razed it during the civil war, their village lay at the foot of Lafon Hill (at top right).



*The chaos and carnage of Sudan's history make it impossible to predict whether the 2005 peace pact will hold through the 2011 vote on independence.*



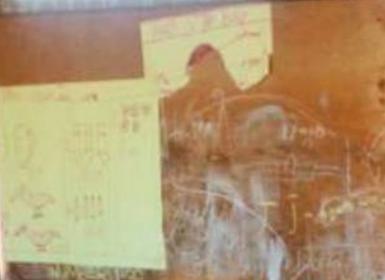
Members of southern Sudan's security service bury two colleagues after the brutal intertribal assault on Duk Padiet. Last year conflicts in the south took 2,500 lives and displaced 350,000. Southerners accused the Khartoum government of stirring up violence to destabilize the region.

WEDNESDAY 13/10/2009

NUMBERS 1-20

1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20				

Aman 3c  
DOD DOD  
DOD DOD





At the Royal Junior School in Bor, students teach until their regular teacher arrives. As basic as this private school is, it offers a better alternative than many of southern Sudan's public schools.



NATIONAL GEOGRAPHIC NOVEMBER 2010



Arms raised like cattle horns, Jacob Mawich celebrates his victory in the election for leader of a Nuer youth association in Juba. Constituents rejected formal paper ballots and voted in the traditional way by lining up behind their man.

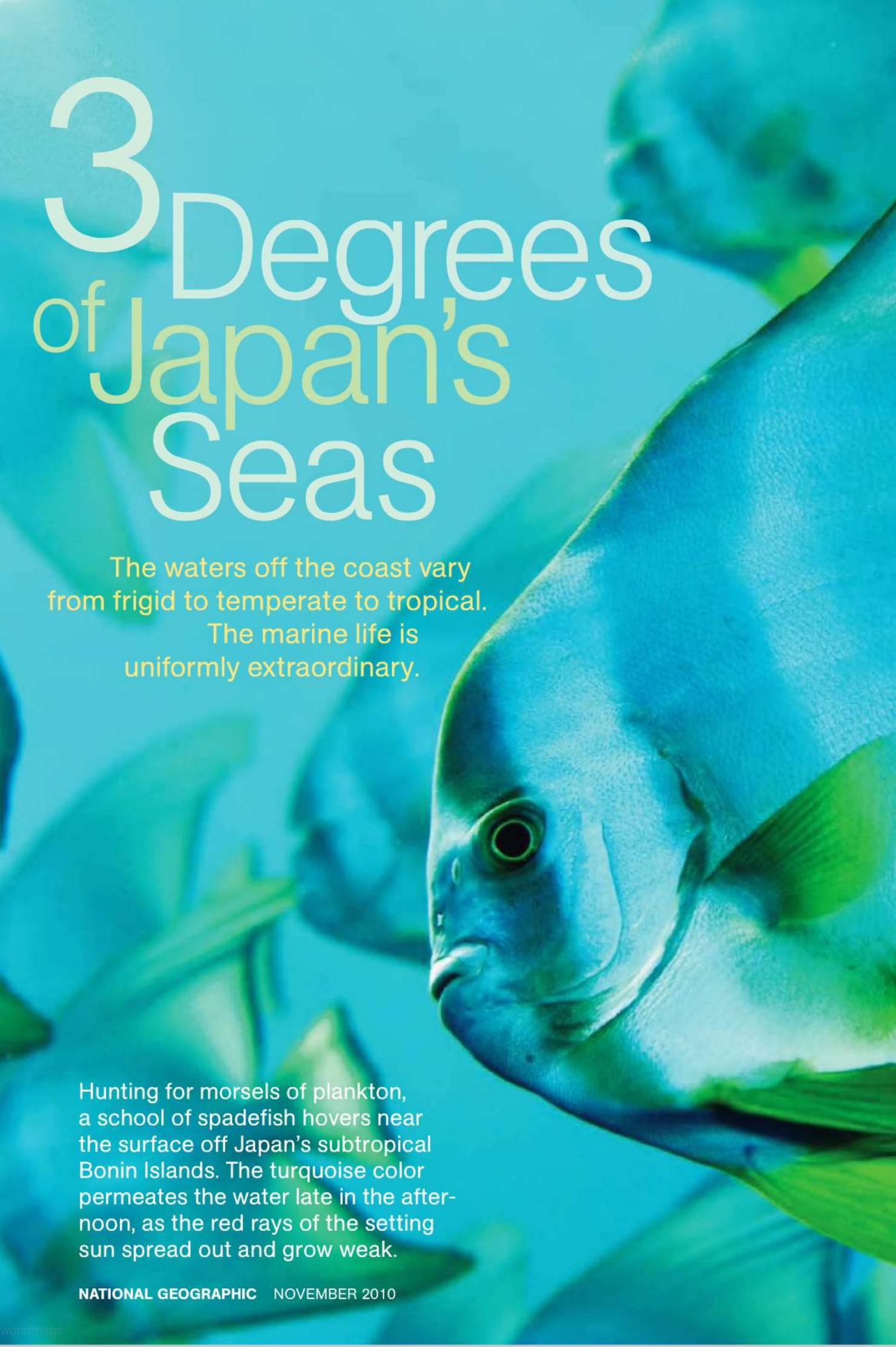


*For countless generations men lived alongside their cows. They named them, decorated them, slept beside them. Sang of them. Danced in their honor. Loved them.*



The connection between a Dinka man and his cow is profound; it is part of his personal identity. The matter of a southern Sudanese national identity is on the table as leaders prepare for next year's referendum on independence, when they hope to persuade Dinka, Nuer, and other feuding tribes to unify.

# 3 Degrees of Japan's Seas



The waters off the coast vary from frigid to temperate to tropical.

The marine life is uniformly extraordinary.

Hunting for morsels of plankton, a school of spadefish hovers near the surface off Japan's subtropical Bonin Islands. The turquoise color permeates the water late in the afternoon, as the red rays of the setting sun spread out and grow weak.





Seventy miles southwest of Tokyo, a moray eel slithers through the branches of a soft coral in the cool waters of Suruga Bay. Deep and narrow, the bay plummets more than 8,000 feet.





The photographer's assistant hangs on to part of an ice canopy that can reach a thickness of 25 feet in winter, blanketing Shiretoko Peninsula waters. A decade ago these seas were icebound an average of 90 days a year. Today the span is about 65 days.



**S**unlight streams between cracks in the ice. Thicker chunks glow emerald green, bejeweled by algae. The characters of this frosty realm begin to appear: a translucent, blue swimming snail, a pink fish with a tail like a geisha's fan, a bright orange lump sucker that looks as if it leaped out of a Pokémon cartoon.

This is the underwater world that awaits photographer Brian Skerry, who is lumbering across the beach near a fishing town called Rausu, in Japan's northeastern corner. Wearing a hooded dry suit and carrying an air tank, hoses, regulator, and 32 pounds of weights, he pulls on his fins and slowly submerges his face to get used to the 29°F water. His lips go numb. And then, camera in hand, Skerry dives between the ice floes into the waters of the Sea of Okhotsk, bordering the Shiretoko Peninsula.

Most people think of Japan as a compact collection of large islands, but a map of the country shows otherwise. Japan stretches over 1,500 miles and includes more than 5,000 islands. As land mingles with sea over these vast distances, it embraces (*Touch Text button to read more.*)

*A contributor to the magazine since 1998, photojournalist and veteran diver Brian Skerry is the author of Face to Face With Manatees.*

Text



On a coral reef in the Bonin Islands, an abandoned wormhole is home to a hermit crab. Unlike its mobile cousins that forage the reef for food, this crab stays put and fishes for floating plankton with its feathery antennae.

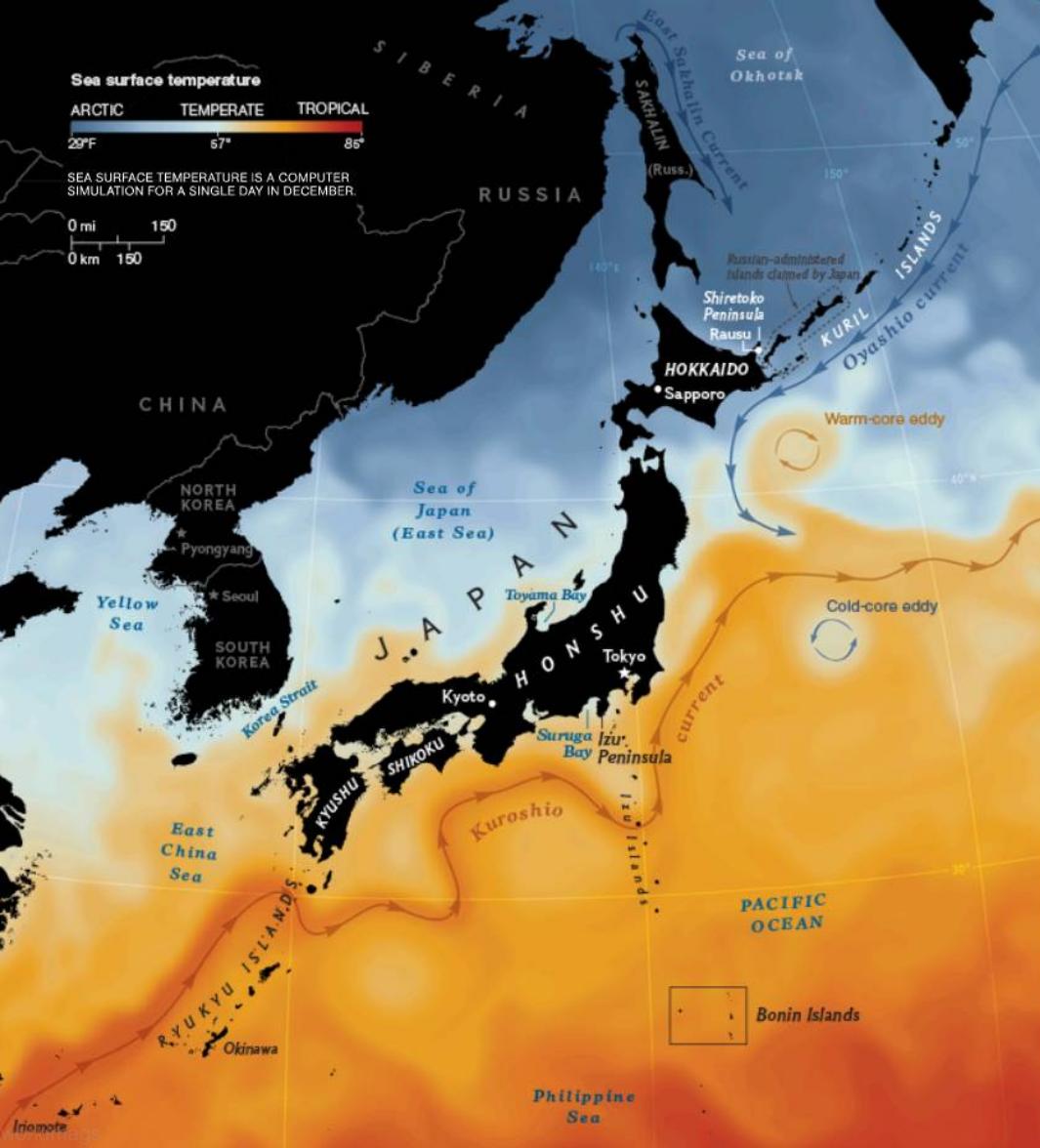


Dive with Brian Skerry to find out his secrets of underwater photography. (1:53)



On a coral reef in the Bonin Islands, an abandoned wormhole is home to a hermit crab. Unlike its mobile cousins that forage the reef for food, this crab stays put and fishes for floating plankton with its feathery antennae.

**Dive with Brian Skerry to find out his secrets of underwater photography. (1:53)**



# Japan's Swirling Seas

Warm and cold ocean currents collide off the coast of Japan, creating a wide range of temperatures. The result is a series of strikingly different marine communities, swept in by the currents.

## East Sakhalin and Oyashio currents

These currents pull cold water from northern latitudes toward Japan.

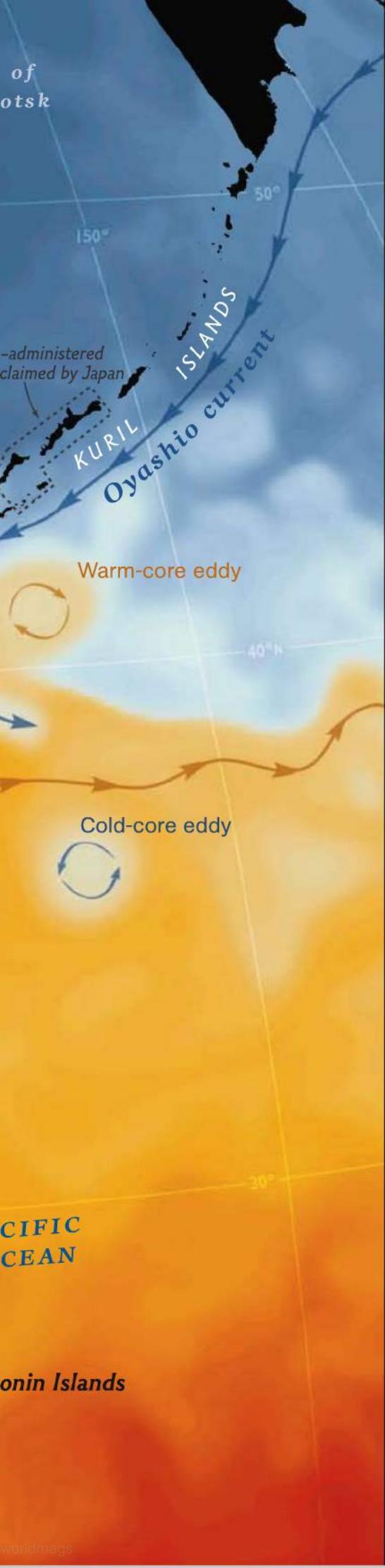
## Eddies

Where currents collide, nutrients from cold water feed warm-water phyto-plankton. The result is a spinning buffet for fish.

## Kuroshio current

Reaching five miles an hour or more, this deep, powerful current ferries warm waters northward along Japan's coast.

VIRGINIA W. MASON, NGM STAFF  
SOURCE: GEOPHYSICAL FLUID DYNAMICS LABORATORY, NOAA



# Japan's Swirling Seas

Warm and cold ocean currents collide off the coast of Japan, creating a wide range of temperatures. The result is a series of strikingly different marine communities, swept in by the currents.

## East Sakhalin and Oyashio currents

These currents pull cold water from northern latitudes toward Japan.

## Eddies

Where currents collide, nutrients from cold water feed warm-water phyto-plankton. The result is a spinning buffet for fish.

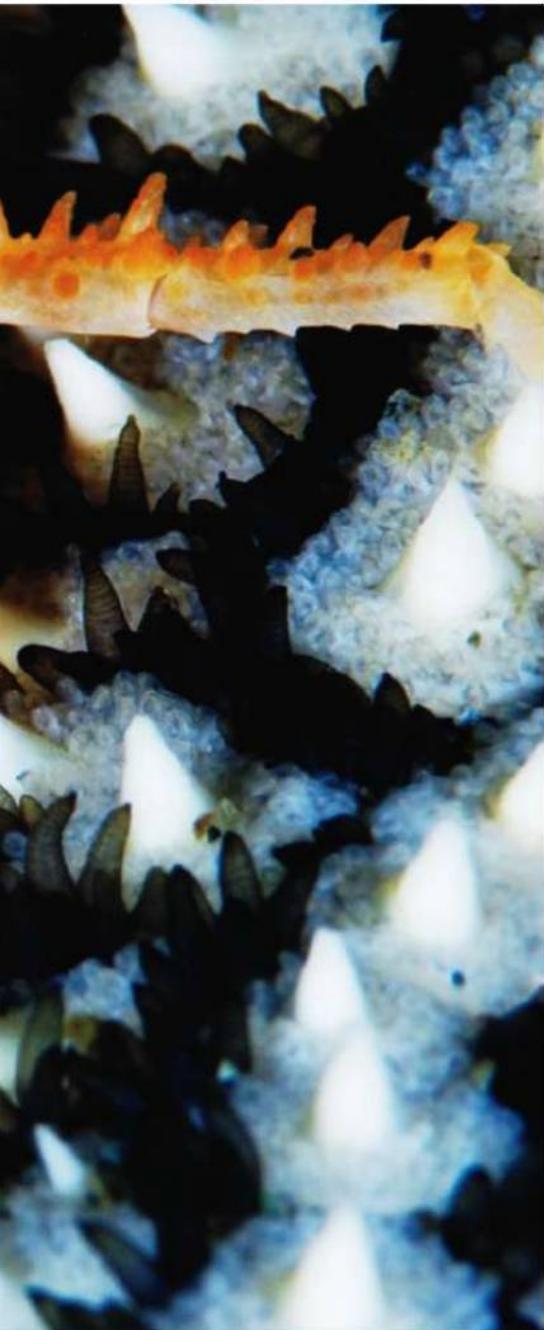
## Kuroshio current

Reaching five miles an hour or more, this deep, powerful current ferries warm waters northward along Japan's coast.

VIRGINIA W. MASON, NGM STAFF  
SOURCE: GEOPHYSICAL FLUID DYNAMICS  
LABORATORY, NOAA



NATIONAL GEOGRAPHIC NOVEMBER 2010



Spikes meet spikes as an Alaska king crab the size of a nickel crawls over a knobby sea star off the Shiretoko Peninsula. After a dozen years, the crustacean will grow to the size of a tractor tire.

# NorthCentralSouth



NorthCentralSouth



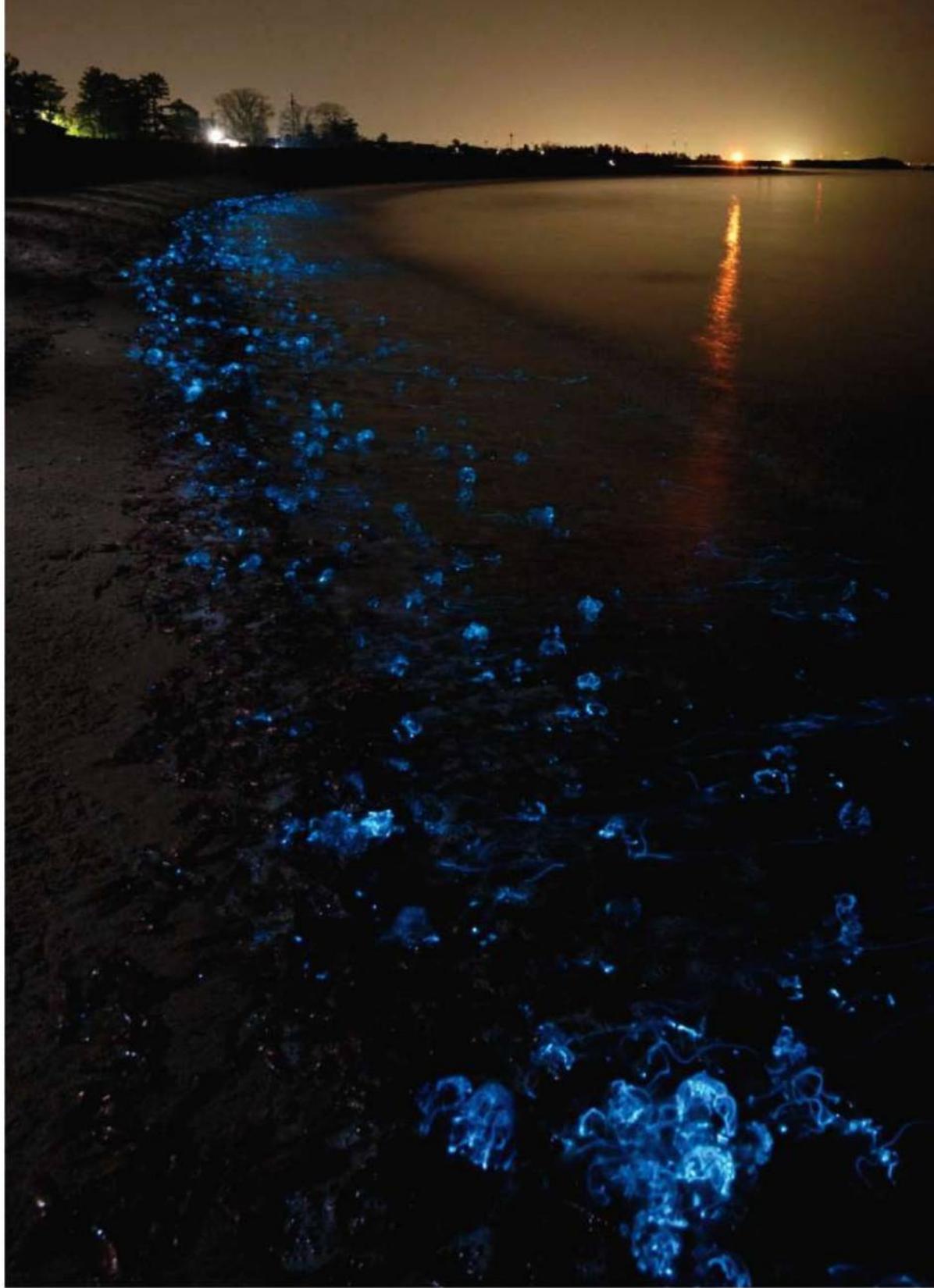
The keen eyes of a Steller's sea-eagle seek the flash of herring between ice floes off the Shiretoko Peninsula.



NorthCentralSouth



In the shallow waters off Hokkaido, a barbed poacher crawls across glistening volcanic sand on spiny pectoral fins. Only the females of this cold-water fish sport a distinctive Pinocchio-like snout.





A volcanic beach off Toyama Bay glows electric blue. The light comes from female firefly squid, which spawn in spring, then die and wash ashore, their tentacles lit like millions of aquamarine LEDs.

# NorthCentralSouth



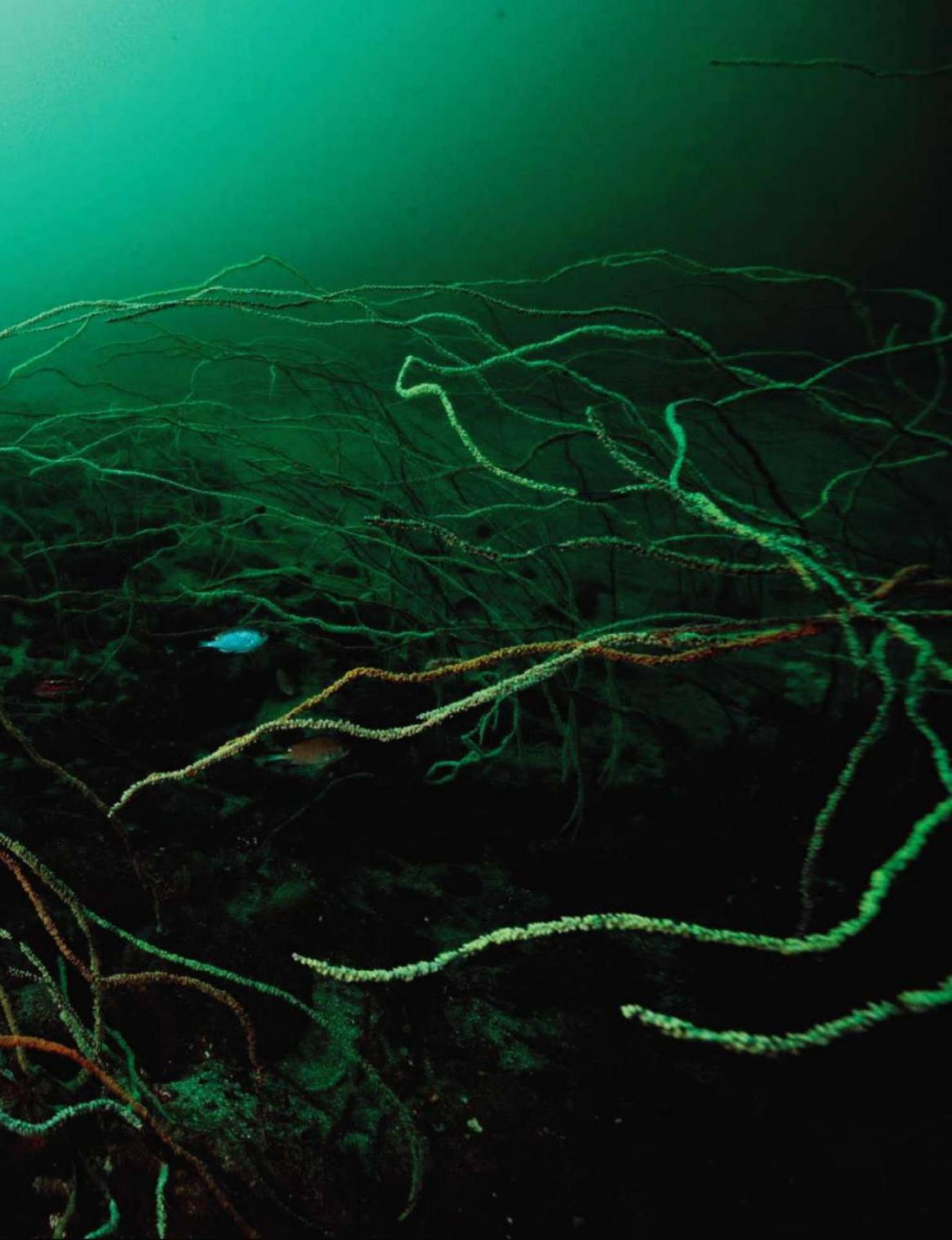
NorthCentralSouth



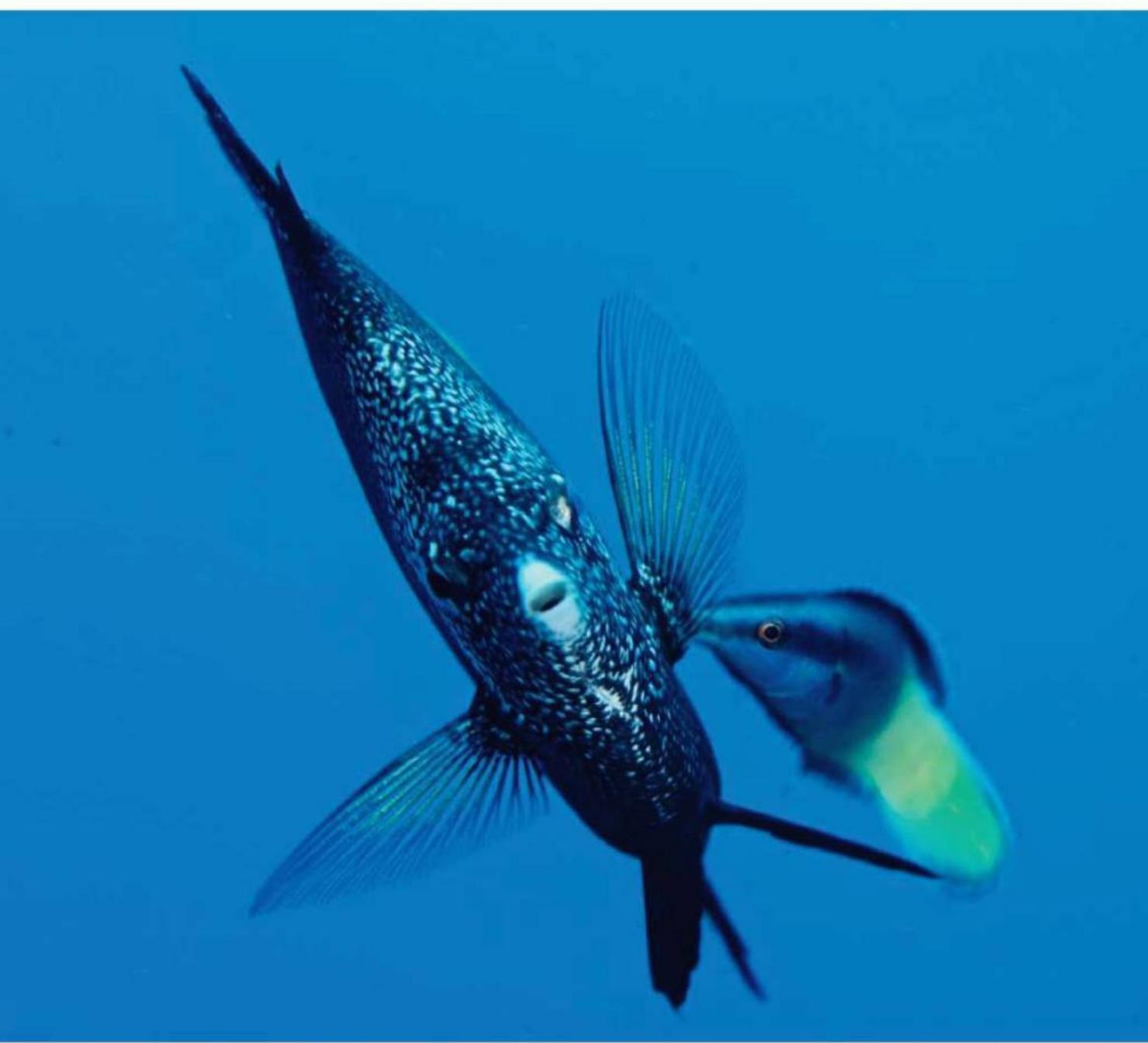
Off the Izu Peninsula, a yellow goby peers through the window of its corroded soda-can home, evidence of the 127 million people just above the water's surface.



NorthCentralSouth



What looks like a tangle of gnarled cables is in fact a forest of deepwater whip coral in Suruga Bay. Each strand is studded with feeding polyps that reach tiny tentacles into the currents to grab floating food.



NATIONAL GEOGRAPHIC NOVEMBER 2010



27°N —  Chichi-shima  
Bonin Islands

Off the Bonin Islands, a wrasse cleans the skin of a wrought iron butterflyfish, whose black-and-white motif evokes the patterns of a samurai kimono.

# NorthCentralSouth

---



NorthCentralSouth



Purple tunicates filter the water for food. They have no scientific name and live behind a single rock in a cave off Chichi-shima island.

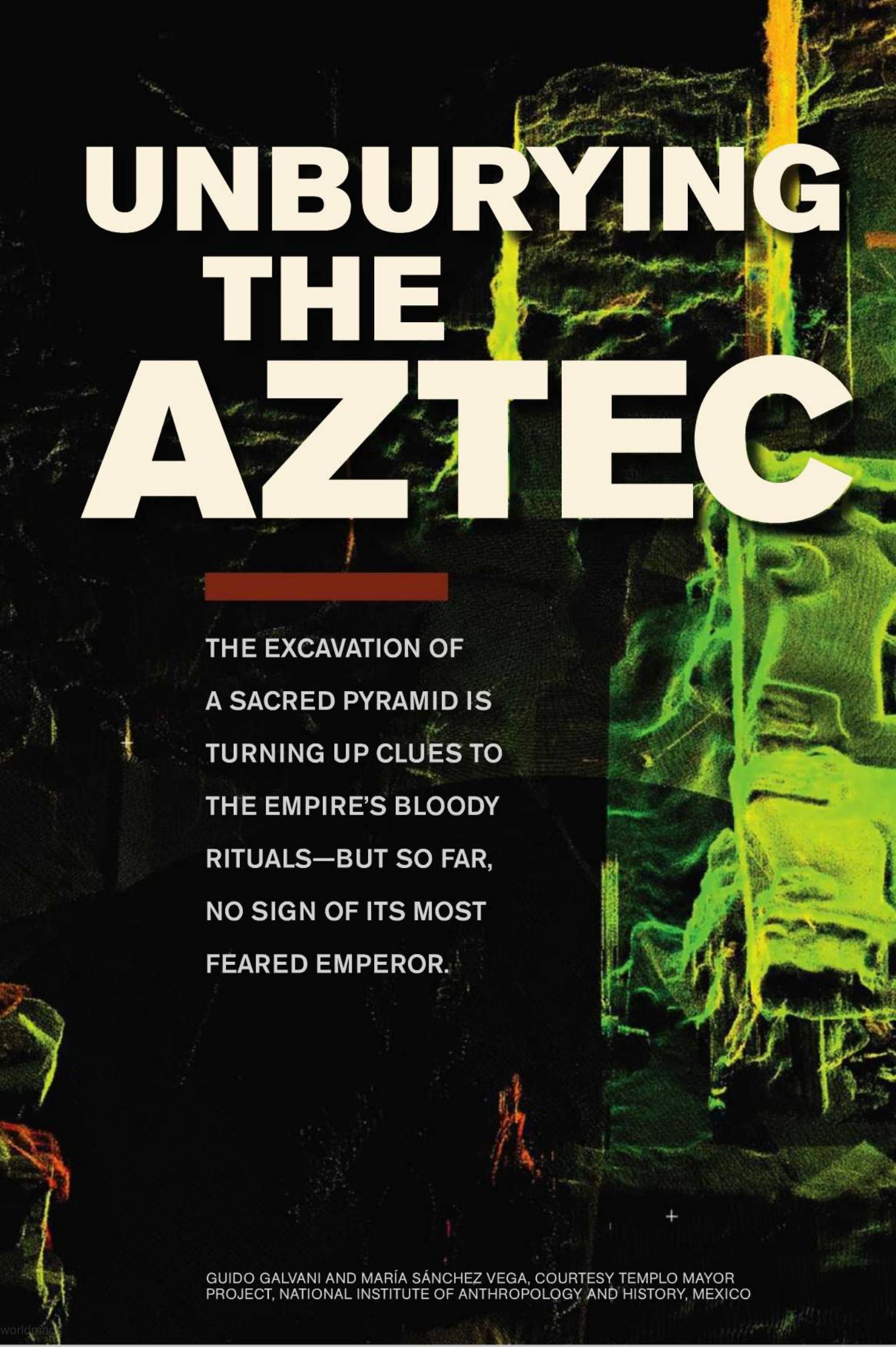


NorthCentralSouth



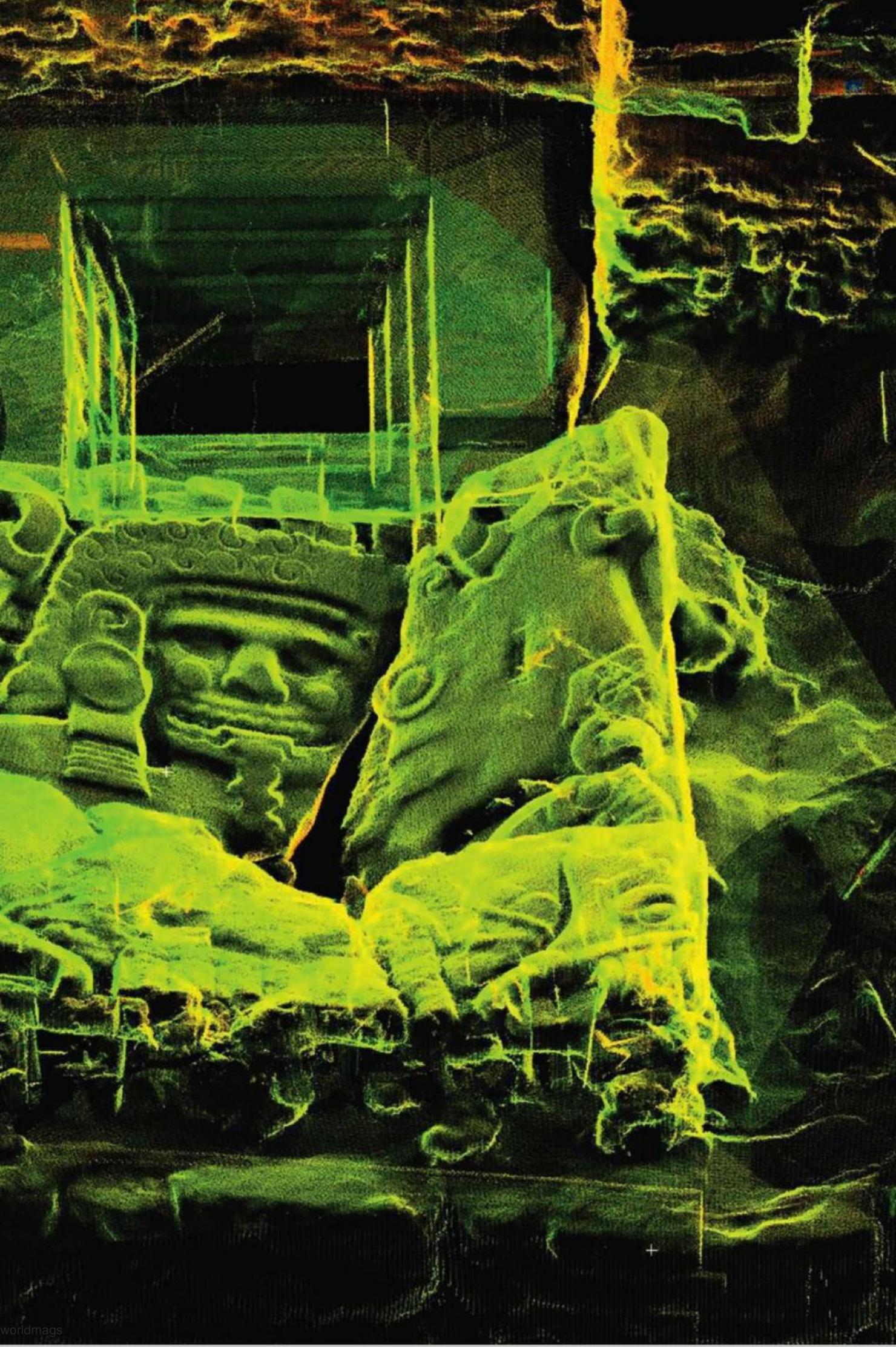
A sand tiger shark off the Bonin Islands will soon give birth. During the nine-month pregnancy, the largest two pups will have eaten their siblings for sustenance, a kind of cannibalism unique to this species.

# UNBURYING THE AZTEC



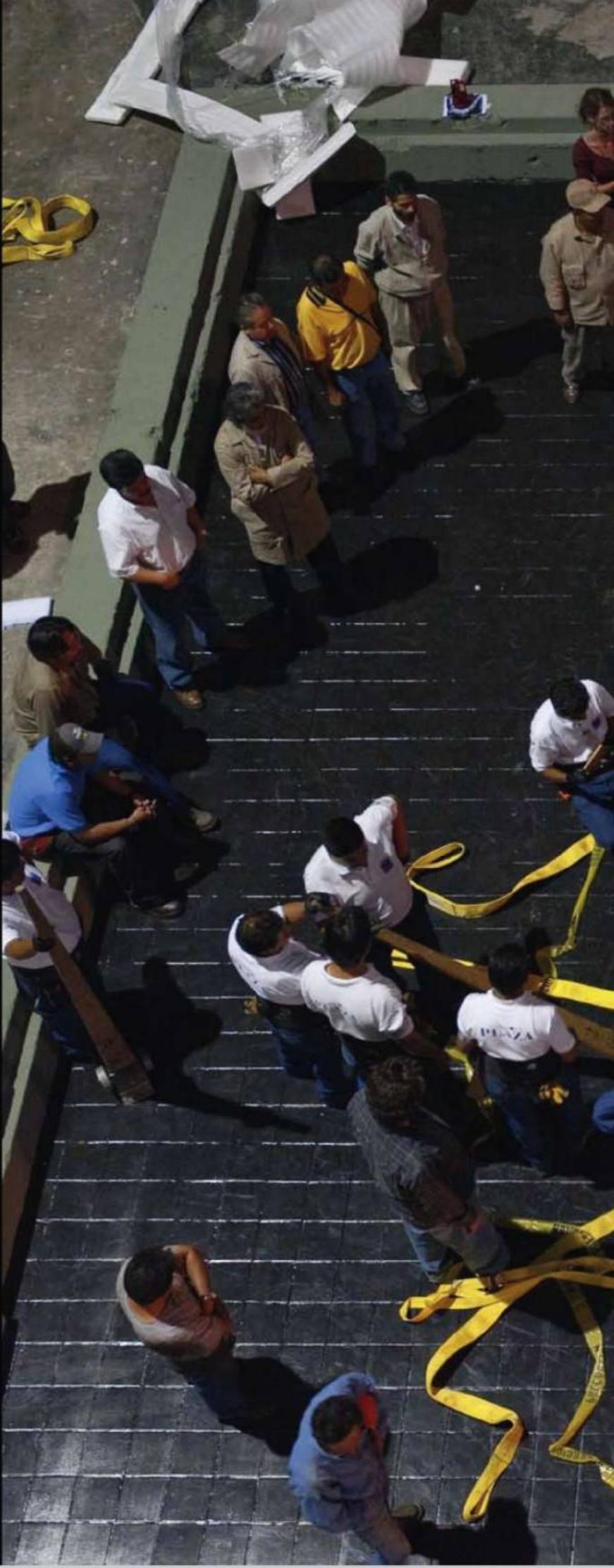
THE EXCAVATION OF  
A SACRED PYRAMID IS  
TURNING UP CLUES TO  
THE EMPIRE'S BLOODY  
RITUALS—BUT SO FAR,  
NO SIGN OF ITS MOST  
FEARED EMPEROR.

GUIDO GALVANI AND MARÍA SÁNCHEZ VEGA, COURTESY TEMPLO MAYOR  
PROJECT, NATIONAL INSTITUTE OF ANTHROPOLOGY AND HISTORY, MEXICO



In May a team of 30 technicians and two cranes took 15 hours to move a 12-ton stone of the earth goddess Tlaltecuhtli, broken into four pieces, about 500 feet from the excavation site to a new home in Mexico City's Templo Mayor Museum. A two-and-a-half-year restoration process has revealed traces of the andesite stone's original ochre, red, blue, white, and black pigments.

While the fractured stone was still in situ, archaeologists used laser-driven pulses of light to produce a green 3-D image of it (see previous spread). In an adjacent shaft lay six offerings of artifacts.





BY ROBERT DRAPER

PHOTOGRAPHS BY KENNETH GARRETT  
AND JESÚS LÓPEZ



**ON THE EDGE OF MEXICO CITY'S FAMED ZÓCALO PLAZA,**

next to the ruins of the Aztec sacred pyramid known as the Templo Mayor, the remains of an animal—perhaps a dog or a wolf—were discovered. It had been dead for 500 years and lay in a stone-lined shaft eight feet deep. It is likely the animal had no name, nor an owner. Yet the anonymous canine had evidently meant something to someone. It wore a collar made of jade beads and turquoise plugs in its ears. From its ankles dangled bracelets with little bells of pure gold.

The archaeological team, led by Leonardo López Lu-ján, unearthed the *(Touch Text button to read more.)*

*Robert Draper is a contributing writer for National Geographic. Kenneth Garrett frequently photographs archaeology stories for the magazine. Photographer Jesús López lives in Mexico City.*

JESÚS LÓPEZ (ABOVE); KENNETH GARRETT (RIGHT)



Its skeleton reassembled for museum display, the animal known as the Aristo-Canine wore a seashell belt and gold bells (left) on its hind legs.

Text



Its skeleton reassembled for museum display, the animal known as the Aristo-Canine wore a seashell belt and gold bells (left) on its hind legs.





Archaeologists, including Ángel González (left), have already recovered tens of thousands of artifacts that will help scholars decode the Aztec view of the universe. The search for a royal tomb has moved to a new tunnel within the Templo Mayor excavation site, part of the remnants of ancient Tenochtitlan in the heart of Mexico City.

JESÚS LÓPEZ (LEFT)



PETER ESSICK

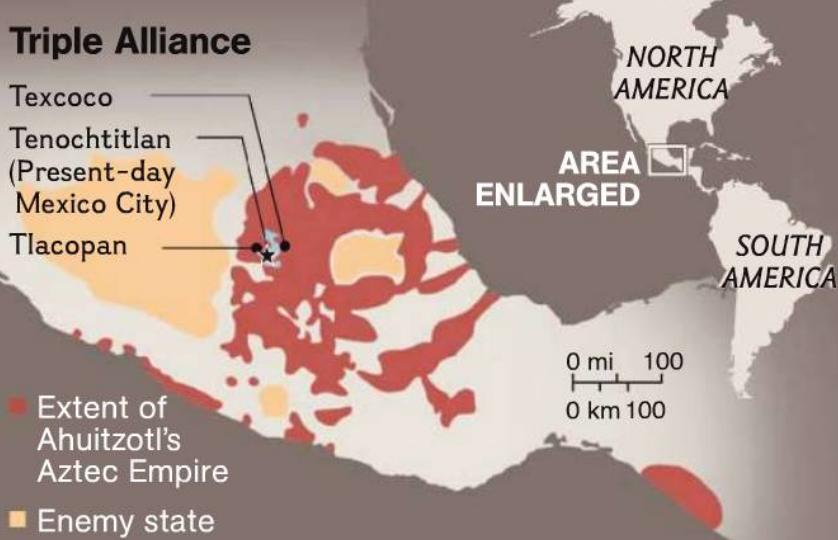
NATIONAL GEOGRAPHIC NOVEMBER 2010



Red, white, and green lights illuminate the ruins of the Templo Mayor for nighttime visitors. Digs have revealed 13 phases of construction from 1375 to 1519, including the pyramid's double staircases.

# AN AZTEC ISLAND HOME

Aztec rulers built a powerful city-state on an island in Lake Texcoco in the Basin of Mexico. Called Tenochtitlan, it was divided by long avenues, criss-crossed by canals, and connected to the mainland by causeways. At its heart was the Sacred Precinct, the empire's religious center, anchored by the Templo Mayor, which was built to unite sky, earth, and worlds below.

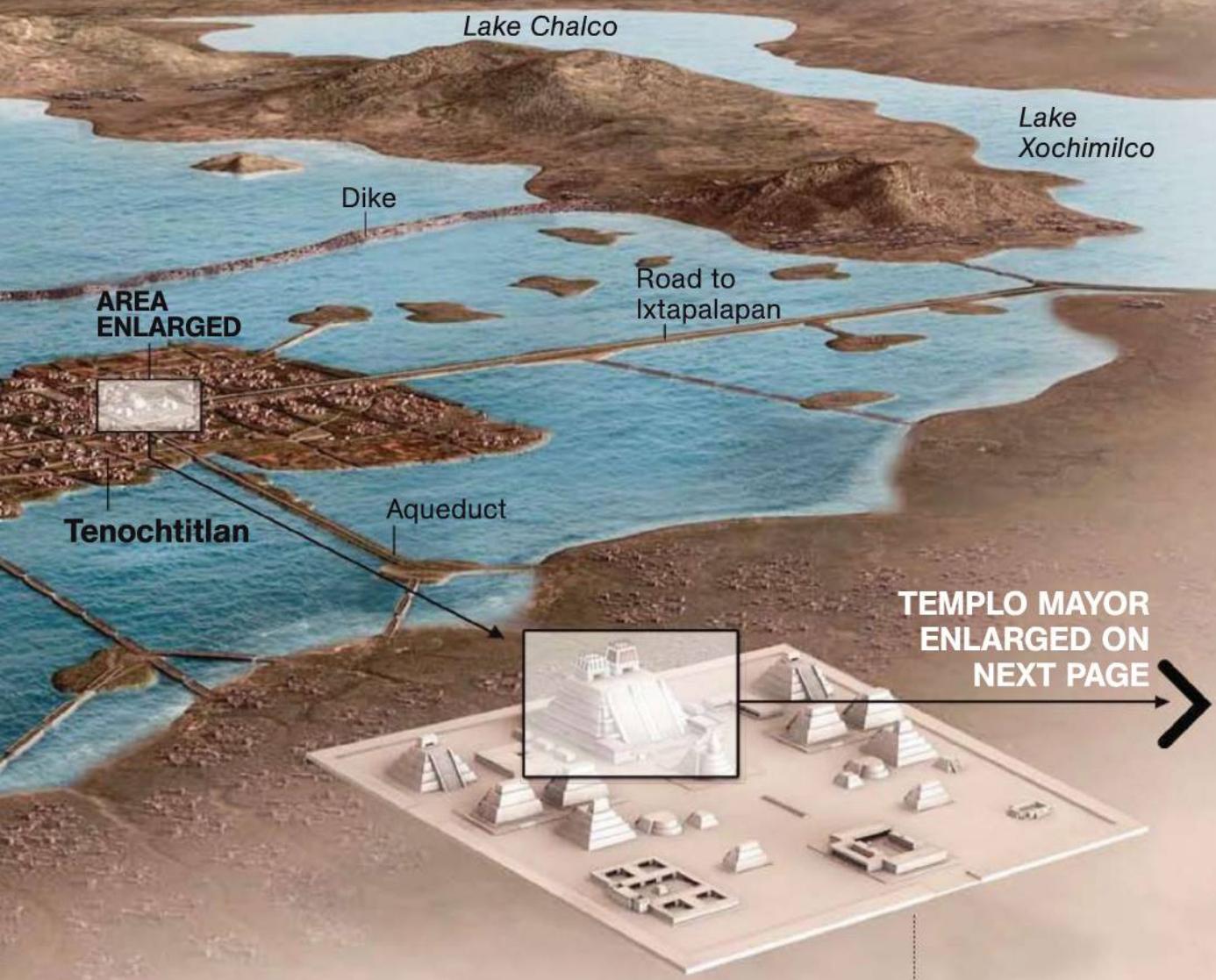


— Iztaccíhuatl —

Popocatépetl —

## Reflection of the Cosmos

The Aztec imagined the universe as a plot of land surrounded by water, with a vertical axis linking 13 heavens and 9 levels of the underworld. Tenochtitlan's grid may have been modeled on that cosmic order.



### Sacred Precinct

Religious rituals and civic life in the city of 200,000 converged on a 30-acre plaza. Inside its walls, shrines and racks of enemy skulls stood in the shadow of the Templo Mayor. The plaza also contained smaller pyramids, schools for nobles, and a ball court.

# TEMPLO MAYOR

A ceremonial theater, the stepped pyramid was topped by two small temples to honor rain god Tlaloc and Huitzilopochtli, god of sun and war. The pyramid towered 150 feet tall.

**Scene depicted circa 1500.**

## Serpent Sculptures

The base of the pyramid was ornamented with sculptures of snakes, linking it to mythical Coatepec—"hill of serpents," a sacred place.



## Ritual Sacrifice

Spilling human blood, priests frequently reenacted the death of goddess Coyolxauhqui at the hands of her brother, Huitzilopochtli—a mythic battle between night and day, female and male.

Shrine to  
Huitzilopochtli



Shrine  
to Tlaloc



SACRED PRECINCT

Coyolxauhqui

DETAIL ON  
NEXT PAGE

## Tlaltecuhtli Stone

Found at the foot of the pyramid, the monolith of the earth goddess was carved of pink andesite quarried six miles away and transported by 200 to 500 men with ropes, poles, and perhaps a balsa raft.

# OFFERINGS TO THE GODS

Beneath the Tlaltecuhtli monolith and in a deep shaft beside it, archaeologists unearthed many offerings, filled with animals, plants, and objects of gold, jade, copper, turquoise, and flint, brought to the temple from all realms of the empire. The Aztec buried objects to worship the gods—a symbolic ritual archaeologists are still decoding.

## **Earth, Sun, Moon**

The largest Aztec monolith yet discovered, the 12-ton earth goddess stone is shown with original red, ocher, blue, white, and black pigments.

Almost seven feet below the monolith itself was offering 126, the largest cache of artifacts found to date and a fitting tribute to Tlaltecuhtli's fertile, feminine nature.

**Tlaltecuhtli Stone  
(Earth Goddess)**  
Found 2006



13.7 x 11.9 ft

**Sun Stone**  
1790



11.7 ft

**Disk of Coyolxauhqui  
(Moon Goddess)**  
1978



10.6 x 10.1 ft



Offering 121

Offering 127

Offering 128

Offering 129

Offering 131

**DETAIL OF  
OFFERING 125  
ON NEXT PAGE**



The offerings in the shaft seem to mark a gateway to Earth's center, rather than to a burial spot, as first thought. The search for royal tombs continues.

# BURIED MEANING

The spatial arrangement of the complex contents of offering box 125 provides clues to a mystery: Were the artifacts layered to represent a soul's journey to Mictlan, the underworld?

## LEVEL 1

The top layer contained gold bells, a spider monkey pelt, jade and gold ornaments, and golden eagles wearing copper.

The eagles faced west, toward the setting sun. Nocturnal power was signified by eight knives "dressed" as lunar deities.

## LEVEL 2

A layer of 62 marine species from the Atlantic and Pacific included crabs, clams, snails, sea urchins, and corals.

The abundant sea life may represent dangerous waters the dead must cross, trekking through nine levels of obstacles.

## LEVEL 3

In the last layer, an aged female dog or wolf wore a jade necklace, olive shell belt, and turquoise earplugs.

Perhaps the jewelry signified a royal pet assigned to guide and protect its master on the dark odyssey.



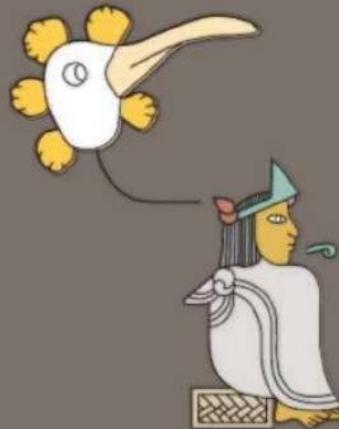
N Offering orientation

# AZTEC RULERS

Tenochtitlan was founded in 1325. Over the centuries only 11 men ruled as *tlatoani*, each with a unique name glyph.



**ACAMAPICHTLI**  
(Handful of Arrows)  
is the first tlatoani,  
hereditary ruler of  
the Aztec city-state.



**HUITZILIHUITL**  
(Hummingbird Feather)  
marries into two rival  
royal families, cement-  
ing alliances.

**1325**

**1375**

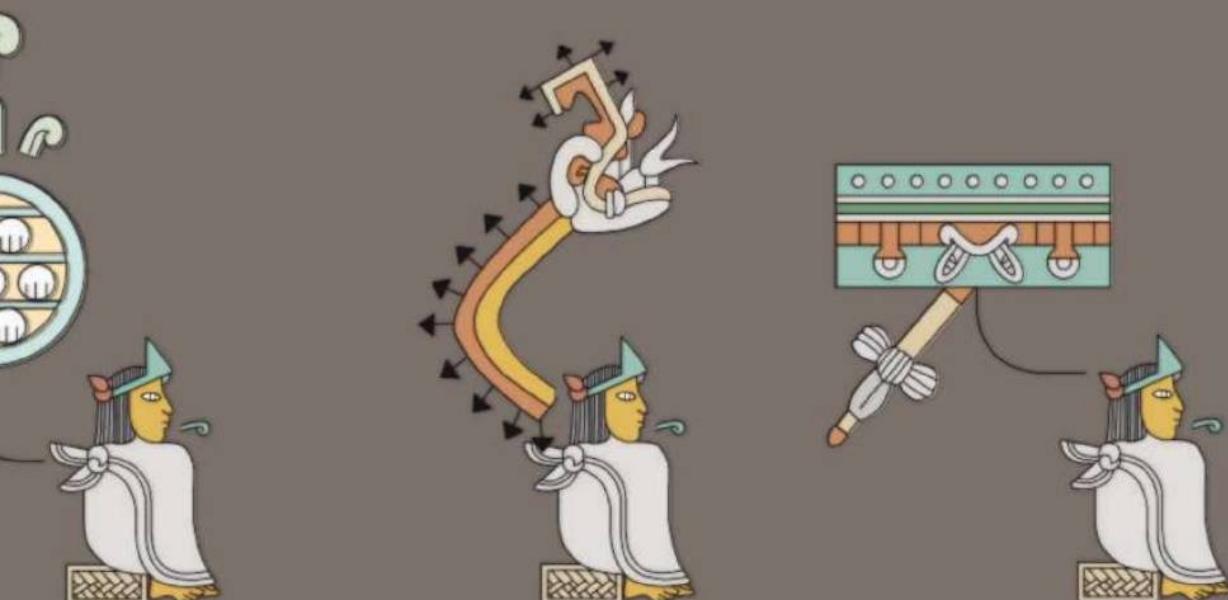
**1395**

1337 The market town of Tlatelolco grows north of Tenochtitlan.

1350 Causeways and canals link Tenochtitlan's neighborhoods.

1396 Huitzilihuitl makes alliances and expands the capital.

MORE



CHIMALPOPOCA  
(Smoking Shield)  
survives ten years  
before he is mur-  
dered by a rival.

ITZCOATL (Obsidian  
Snake) joins leaders  
of Tlacopan and  
Texcoco in mobiliz-  
ing a new empire.

MOCTEZUMA ILHUICAMINA  
(Angry Lord, He Shoots the  
Sky) expands the empire  
using elite warriors, includ-  
ing “eagle lords.”

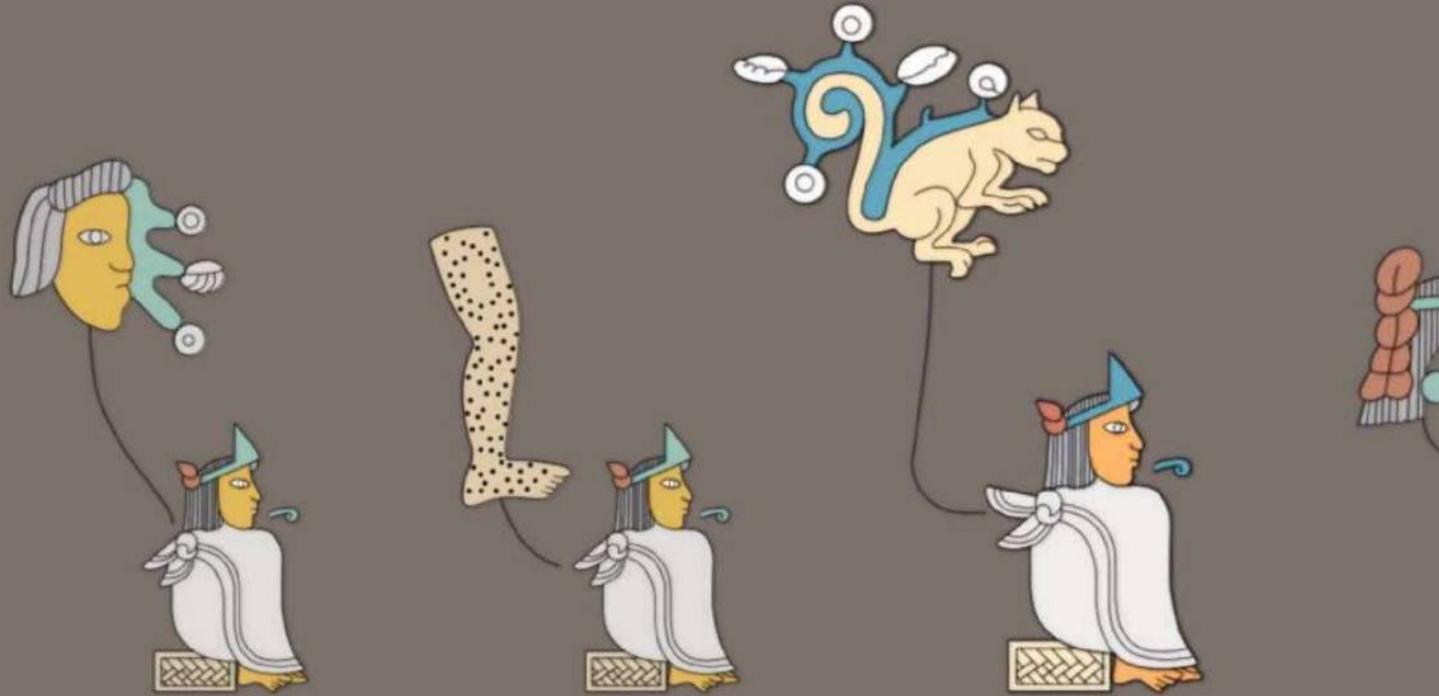
1417

1427

1440

1427-1430 An alli-  
ance led by Tenoch-  
titlan wins control  
of central Mexico.

1450-54 Floods,  
then severe drought  
and famine, plague  
the Basin of Mexico.



AXAYACATL (Water Face) attacks the Tarascan people but loses the war and 20,000 men.

TIZOC (Chalk Leg), brother to Axayacatl and Ahuitzotl, rules weakly and is assassinated.

**AHUITZOTL** (Water Beast) conquers new lands and is called *huey tlatoani*, or great speaker.

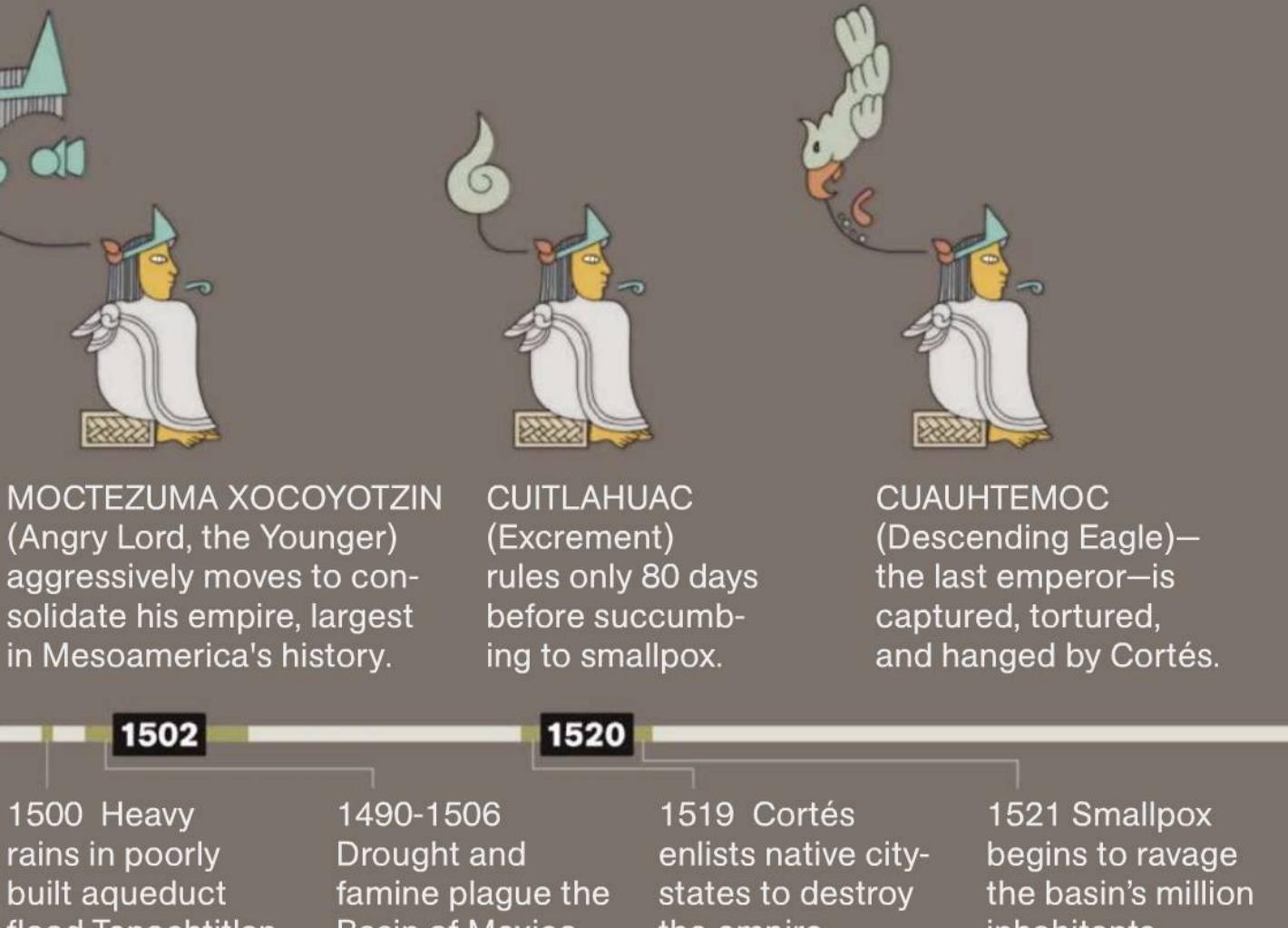
1469

1481

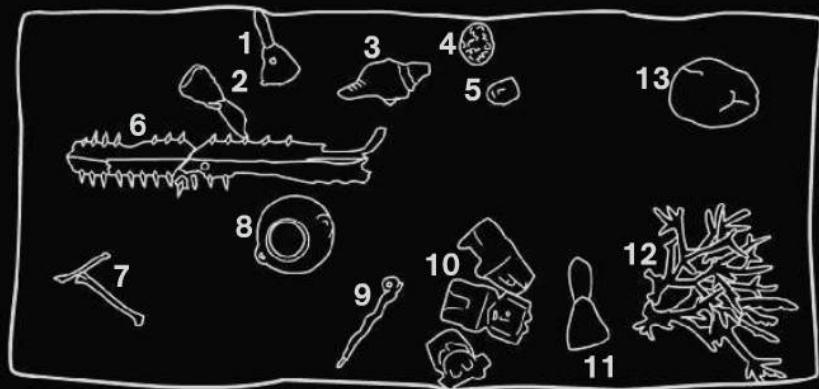
1486

1473 Tenochtitlan subjugates Tlate-lolco and rises to dominant city-state.

1487 Templo Mayor is rededicated with the blood of thousands.



ALEJANDRO TUMAS; SHELLEY SPERRY. ART: HERNÁN CAÑELLAS. MAP: MAGGIE SMITH  
SOURCES: LEONARDO LÓPEZ LUJÁN, TEMPLO MAYOR PROJECT, INAH; FRANCES F. BERDAN, CALIFORNIA STATE UNIVERSITY, SAN BERNARDINO; JULIANA NOVIC AND MICHAEL E. SMITH, ARIZONA STATE UNIVERSITY; EMILY UMBERGER, UNIVERSITY OF ARIZONA



Directly under Tlaltecuhtli, the largest offering yet unearthed (box 126, right, and drawing above) held shells and corals (3, 4, 12, 13), tiny pine masks (5), a sawfish bill (6), 8,500 animal bones (7), a jar of grain (8), a scepter (9), fire god sculptures (10), and flint and copal knives similar to one shown above (1, 2, 11).



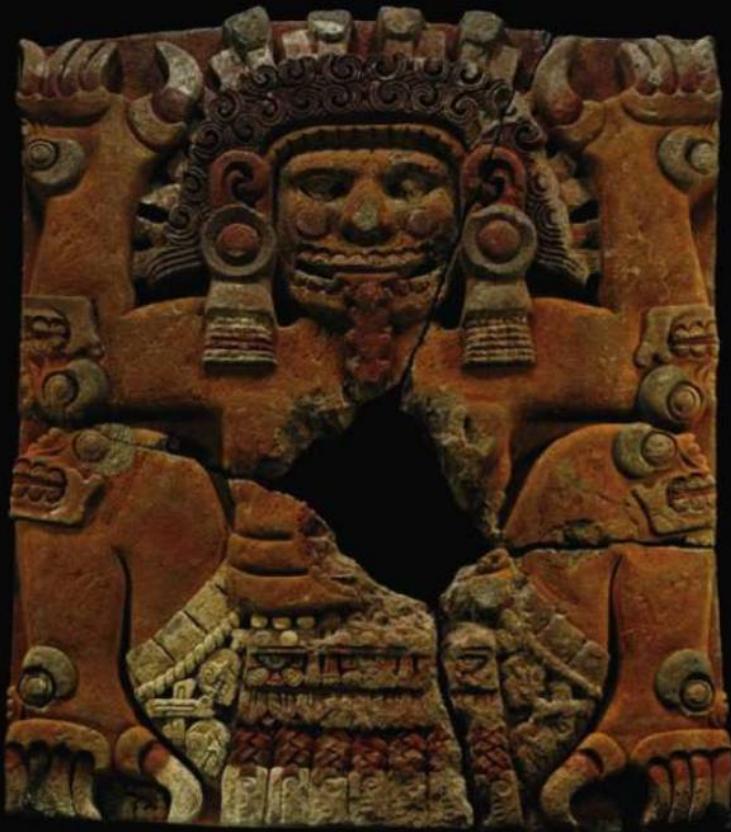






Inside the shaft beside the monolith, archaeologists found offering box 125, depicting what project leader López Luján calls a “miniature image of the universe.” Among the treasures offered to the gods were a gold ornament (above, top) and a greenstone necklace (above). Opposite is one of the tiny pine masks found in box 126.





The missing piece at the center of the monolith of the earth goddess was never found. Right: Art depicts Ahuitzotl's funerary bundle, in turquoise diadem and mask, being carried to his pyre.



# INSIDE GEOGRAPHIC

## SPECIAL ISSUE

**Sacred Journeys** What is it about a place that compels us to travel there for spiritual sustenance? From Mecca to Vatican City, destinations the world over draw throngs of people seeking religious fulfillment. Yet for many others a hike to Mount Fuji or a walk in the woods also offers a powerful experience—and a holiness of its own. Explore some of Earth's most fascinating and important spiritual sites in *Sacred Journeys*, featuring a map of major pilgrimages and places and an essay by *National Geographic*'s senior editor Don Belt. This new *National Geographic* special issue is available in bookstores November 2 or at [ngm.com/sacred-journeys](http://ngm.com/sacred-journeys) (\$10.99).

---

## NG BOOKS

Brilliantly illustrated with more than 250 color photographs, *Great Migrations* is the essential companion to the television series of the same name. This book will captivate animal lovers and environmentalists alike with its in-depth coverage of the never-before-seen wildlife behavior and stories showcased in the groundbreaking documentary. Other highlights include archival images and unforgettable film stills. Look for *Great Migrations* in bookstores in mid-October (\$35).

FREE  
MAP  
**WORLD  
FAITHS**

Pilgrimage Sites From Stonehenge to Galilee

SPECIAL EDITION

# NATIONAL GEOGRAPHIC

ESSAY:  
SEARCHING FOR  
MIRACLES

Earth's  
Holiest  
Places

# SACRED JOURNEYS

OUR LADY OF FÁTIMA,  
PORTUGAL

NATIONAL  
GEOGRAPHIC

## FLASHBACK

**Modern Mermaids** A Japanese ama goes overboard in search of shellfish in the 1930s. For centuries these female free divers worked the country's coasts without much clothing, but that changed: "Except for a few older women, the ama of Hekura no longer dive semi-naked," wrote Luis Marden after visiting one group of divers. His July 1971 *Geographic* story, "Ama, Sea Nymphs of Japan," goes on to say, "The girls wore black leotards. Most others wore all-enveloping suits of black neoprene, the diver's wetsuit."

There aren't many ama left in Japan. Most who remain are middle-aged or older; divers sometimes work into their 80s. Today few young women care to take the plunge. —Margaret G. Zackowitz



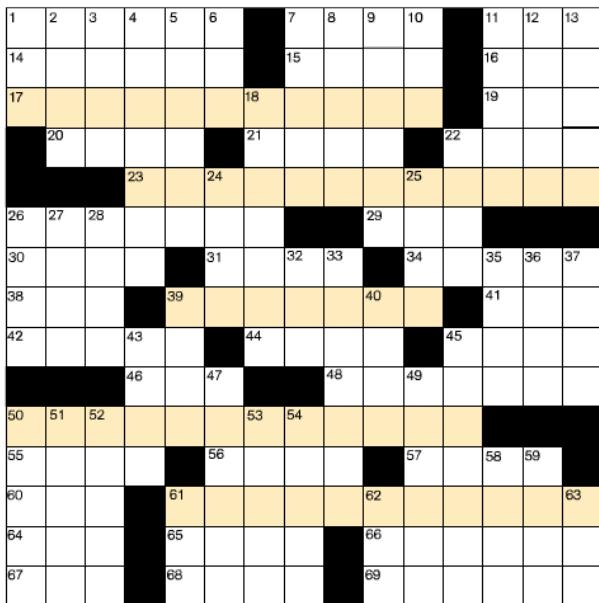
PHOTO: EUROPEAN PICTURE SERVICE/NATIONAL GEOGRAPHIC STOCK

NATIONAL GEOGRAPHIC NOVEMBER 2010



# G E O P U Z Z L E

[Click here](#) for the answers.



## ACROSS

- 1 Marine animal that's no square
- 7 Little lumps
- 11 Mount Rushmore prez
- 14 Rescuer
- 15 Oaxacan "other"
- 16 Roman goddess of peace
- 17 Choice an arctic tern might face when offered a mid-migration herring
- 19 Terre Haute sch.

- 20 Make out, in Liverpool
- 21 Hydrodynamic duo
- 22 Inn need
- 23 With 50 Across, prairie rattlers' migration scheme?
- 26 Language of Manila
- 29 Schmooze
- 30 Prefix with lateral
- 31 Smooth-talking
- 34 Passerine's perch
- 38 Not talking

## DOWN

- 1 Former fast flier to JFK
- 2 Goals on greens
- 3 Tandoor, e.g.
- 4 Russian form of the saint aka Santa
- 5 Ten to the hundredth power
- 6 Mix metaphors, say
- 7 Org. that "tracks" Santa
- 8 Prenatal "nurseries"
- 9 Loud and overbearing
- 10 He's hardly a teetotaler
- 11 Like some drones
- 12 Rudimentary
- 13 Radiate, as confidence
- 18 Does some back-and-forth switching
- 22 Shark type
- 24 Bagged launch
- 25 Infield protector
- 26 One working in a sub way
- 27 Blue hue
- 28 Checkout-aisle assortment
- 32 Suffix akin to "-ian"
- 33 Where suds are made and served
- 35 Mideast sultanate
- 36 It gets reefed
- 37 Award for *Bye Bye Birdie*
- 39 Skinniness exemplar
- 40 Superstar
- 43 \_\_\_ crier
- 45 Thoroughbred grandfather of Seabiscuit
- 47 Surgically tie
- 49 Actress Mason in *The Goodbye Girl*
- 50 Mating game
- 51 Scamp
- 52 Bakery lure
- 53 Subject of SALT I and II
- 54 Like nu
- 58 Did a round
- 59 Sandusky's lake
- 61 Wee bit
- 62 Fashion designer's monogram
- 63 Deface

- 39** Chinook salmon's migration to its birthplace for egg laying?
- 41** Long March leader
- 42** Capellini or cannelloni
- 44** Brazil nut, botanically
- 45** Chief
- 46** Enemy in this year's Gulf "war"?
- 48** Feminine
- 50** See 23 Across
- 55** Cape of Chile
- 56** Spiritual adviser
- 57** Its hips may be in tea
- 60** It's behind hubris
- 61** Overwhelm like monarch butterflies during their migration?
- 64** Abacus calculation
- 65** Suit to \_\_
- 66** Grammy winner Twain
- 67** Salmon's first migration destination
- 68** Place for a modesty panel
- 69** Swans vis-à-vis swallows
- 11** Like some drones
- 12** Rudimentary
- 13** Radiate, as confidence
- 18** Does some back-and-forth switching
- 22** Shark type
- 24** Bagged launch
- 25** Infield protector
- 26** One working in a sub way
- 27** Blue hue
- 28** Checkout-aisle assortment
- 32** Suffix akin to "-ian"
- 33** Where suds are made and served
- 35** Mideast sultanate
- 36** It gets reefed
- 37** Award for *Bye Bye Birdie*
- 39** Skinniness exemplar
- 40** Superstar
- 43** \_\_ crier
- 45** Thoroughbred grandfather of Seabiscuit
- 47** Surgically tie
- 49** Actress Mason in *The Goodbye Girl*
- 50** Mating game
- 51** Scamp
- 52** Bakery lure
- 53** Subject of SALT I and II
- 54** Like nu
- 58** Did a round
- 59** Sandusky's lake
- 61** Wee bit
- 62** Fashion designer's monogram
- 63** Deface

## DOWN

- 1** Former fast flier to JFK
- 2** Goals on greens
- 3** Tandoor, e.g.
- 4** Russian form of the saint aka Santa
- 5** Ten to the hundredth power
- 6** Mix metaphors, say
- 7** Org. that "tracks" Santa
- 8** Prenatal "nurseries"
- 9** Loud and overbearing
- 10** He's hardly a teetotaler

PUZZLE BY CATHY ALLIS

## NEXT MONTH



A herder serenades his goats near Jerusalem.

PHOTO: GREG GIRARD

## December 2010

### **Veiled Rebellion**

Afghan women are starting to fight for a just life.

### **A Serenade to Swans**

The whooper swan is a bird to inspire flights of fancy.

### **David and Solomon**

Archaeologists dig up controversy as they dig into the kings.

### **Heart of the Milky Way**

The black hole at the galaxy's center is giving up its secrets.

### **Alaska's Choice**

In Bristol Bay, the debate is on: gold mine versus salmon runs.

### **Bat Crash**

A fungus has killed at least a million U.S. bats.